D4.4 - ERV-Tool User Guide

A practical and concise guide for the utilization of the ERV-Tool

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Executive Summary

The objective of the ERV-tool is to allow the evaluation and bundling of energy efficiency investments in the residential sector. Its main features are:

- Engineering, financial and risk analyses all integrated in one tool
- Simple modular structure to develop comprehensive analyses
- User friendly interface for calculations development
- Broad range of results available for undertaking investment decisions

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Objectives of the RenOnBill Tool

The RenOnBill Tool aims to:

- Simplify the estimation of energy savings for "*non-technical users*"
- Provide an adequate degree of flexibility for "*technical users*"
- Develop a complete financial analysis by including a probabilistic approach
- Bundle investments for an overall evaluation

Development of quite a flexible tool adequate for *technical* and *non-technical* users in the development of complex analyses of energy renovation interventions for the residential sector

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Introduction to the RenOnBill Tool 1/2

- **The tool provides a simple, yet effective instrument to test the energy and economic feasibility of energy-focused renovation interventions on a selected group of dwellings belonging to one or more cities, and different countries**. Possible interventions cover various aspects of the energy profile of a building; from the change of heating and DHW gears to the renovation of the windows/frames' equipment to the introduction of wall/roof/floor insulation means. Solar energy integration is considered too.
- The analysis starts from **the comparison between a given situation**, estimated by simulating the current status of the building, **and a planned renovated one.**
- **The software, will provide three different analyses and is structured in three functional modules**. **The first, the Engineering Module, provides the building energy balance**: energy flows and internal gains are evaluated also by taking into account the external weather conditions of the selected location. The calculated energy needs are then satisfied by a proper equipment set-up. Energies are monetized and translated to user bill loads based on the electric and fuel in the considered Country.
- **Since almost all the parameters involved are, to some extent, random, a Monte Carlo analysis is performed to evaluate the expected values** of the desired quantities and their uncertainty. In this way, all the relevant information, e.g. energy savings, can be obtained in the form of an expected value along with its confidence bounds.

Introduction to the RenOnBill Tool 2/2

- **The second module of the tool, the Economic Module, provides various indicators about the performance of the investment.** A comparison between fixed investment costs and wished savings is performed, both in deterministic and in the stochastic regime, to obtain a realistic Net Present Value (NPV) of the intervention along with the risk associated with it. As known, the more consistent the group of dwellings considered, the less volatile the results of the investment. Various financial indices will be considered: Net Present Value (NPV), Internal Rate of Return (IRR), Pay Back Period (PBP), Profitability Index (PI) and others. "At Risk" performance of several parameters is presented too.
- **The third module provides the overall score of the project, obtained by a combination of Engineering (savings), Financial (IRR) and Commercial (churn rate and default rate) performance parameters.**
- These two last parameters account for the solidity of the client by quantification of its commercial relationship with the energy utility, e.g. the client's default rate in paying energy bills, loyalty to the utility, and the average level of energy consumption.
- The last section is dedicated to the estimation of the so-called "non energy benefits".

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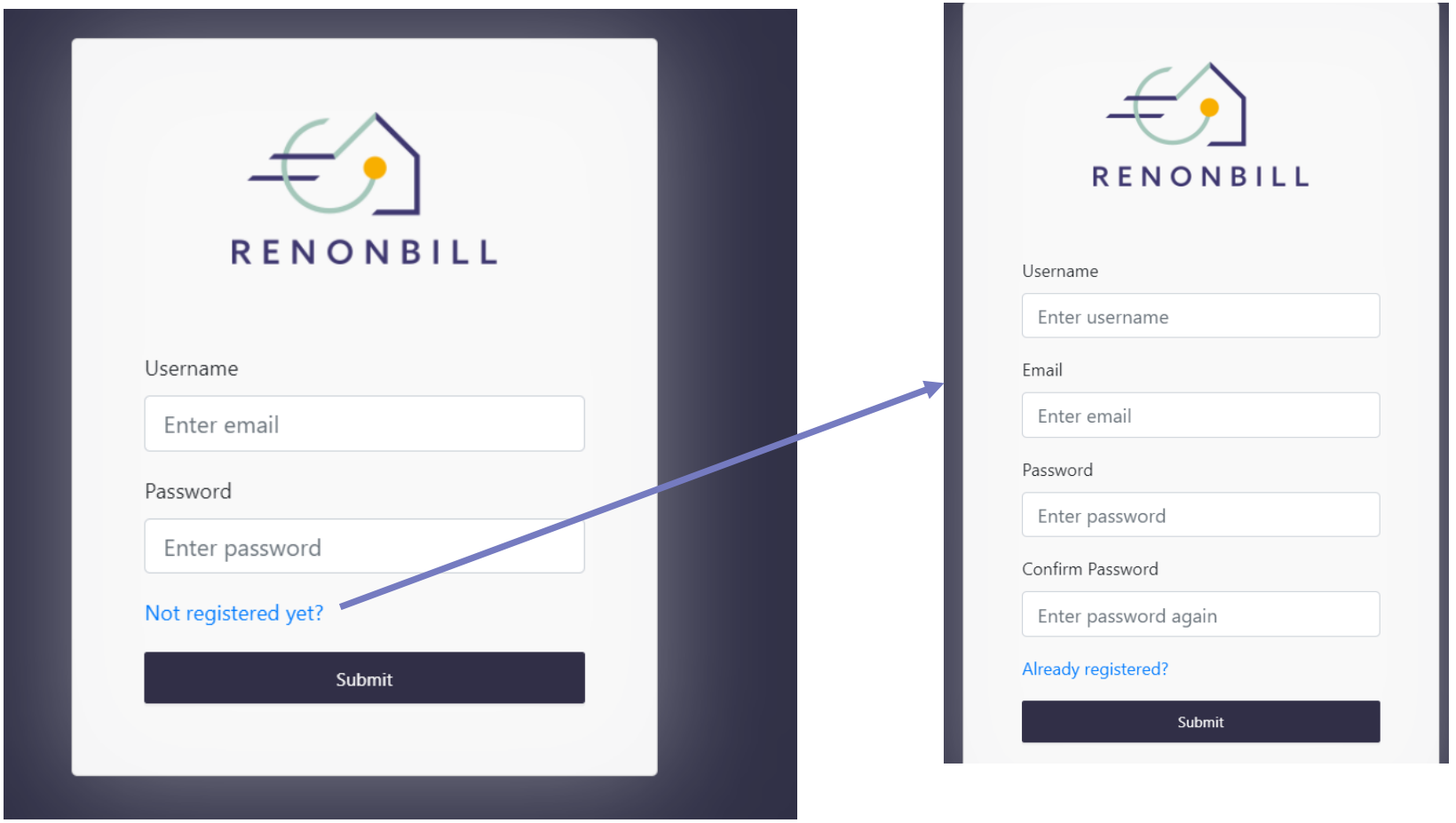
Access to the Tool

Access to the Tool: Register with a username and password to be used for accessing to your area where you can save your projects.



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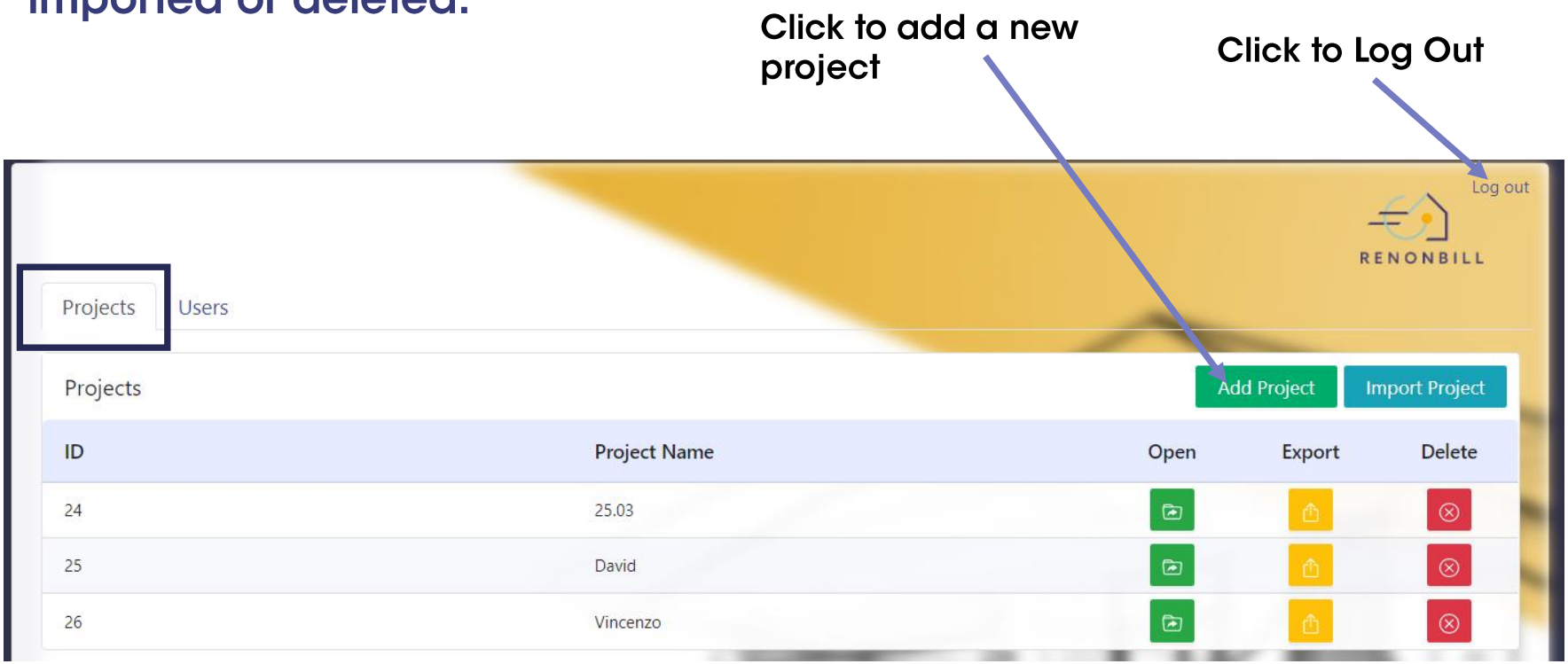
Initial Page

This is the user area where projects can be created, opened, exported, imported or deleted.



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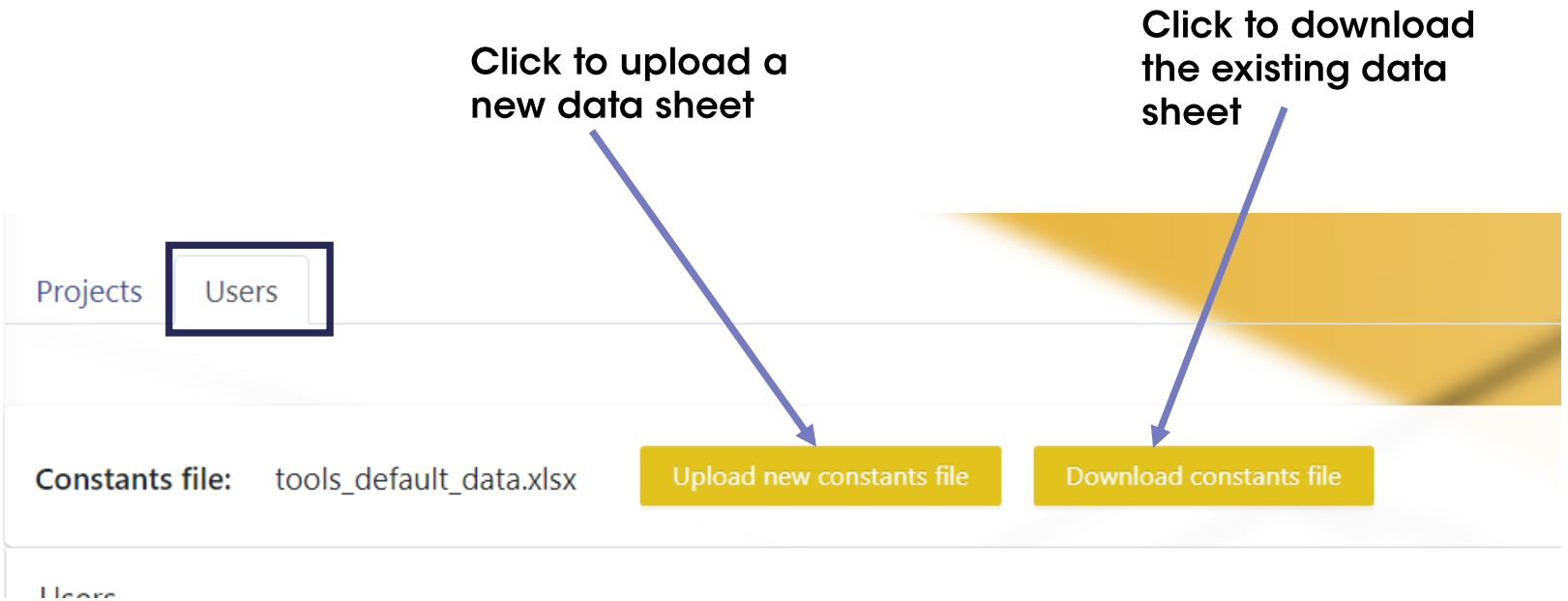
Modify Data Sheet 1/2

The tool uses a Data Sheet which is a database containing info on the cost of the interventions, energy prices, climatic data, etc. This file can be modified by the user and uploaded in the tool. The structure of the Data Sheet is discussed in the corresponding section of this guide.



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Modify Data Sheet 2/2

If you scroll down, you can read the data uploaded in the data sheet.
You can only consult; no special operation can be executed.

Constants

City Climate | Thermal Data | Envelope Windows | Heating & DHW | Other Thermal Data | Variable Costs | Default Uncertainty

Uncertain Variables

Data

Country	City	HDD	Zone	Heating on/off	Average Daily Solar Rad	January	February	March
Italy	Agrigento	729	B	01.12/31.03		13.8	15.4	14.4
Italy	Alessandria	2559	E	15.10/15.04		8.4	10.2	11.1
Italy	Ancona	1688	D	01.11/15.04		6.6	9.7	11.3
Italy	Aosta	2850	E	15.10/15.04		10.3	11.6	12.1
Italy	Arezzo	2104	E	15.10/15.04		8.6	9.7	10.2
Italy	Ascoli Piceno	1698	D	01.11/15.04		8.8	10.4	11.6
Italy	Asti	2617	E	15.10/15.04		9.4	10.9	11.6
Italy	Avellino	1742	D	01.11/15.04		8	10.1	11.1

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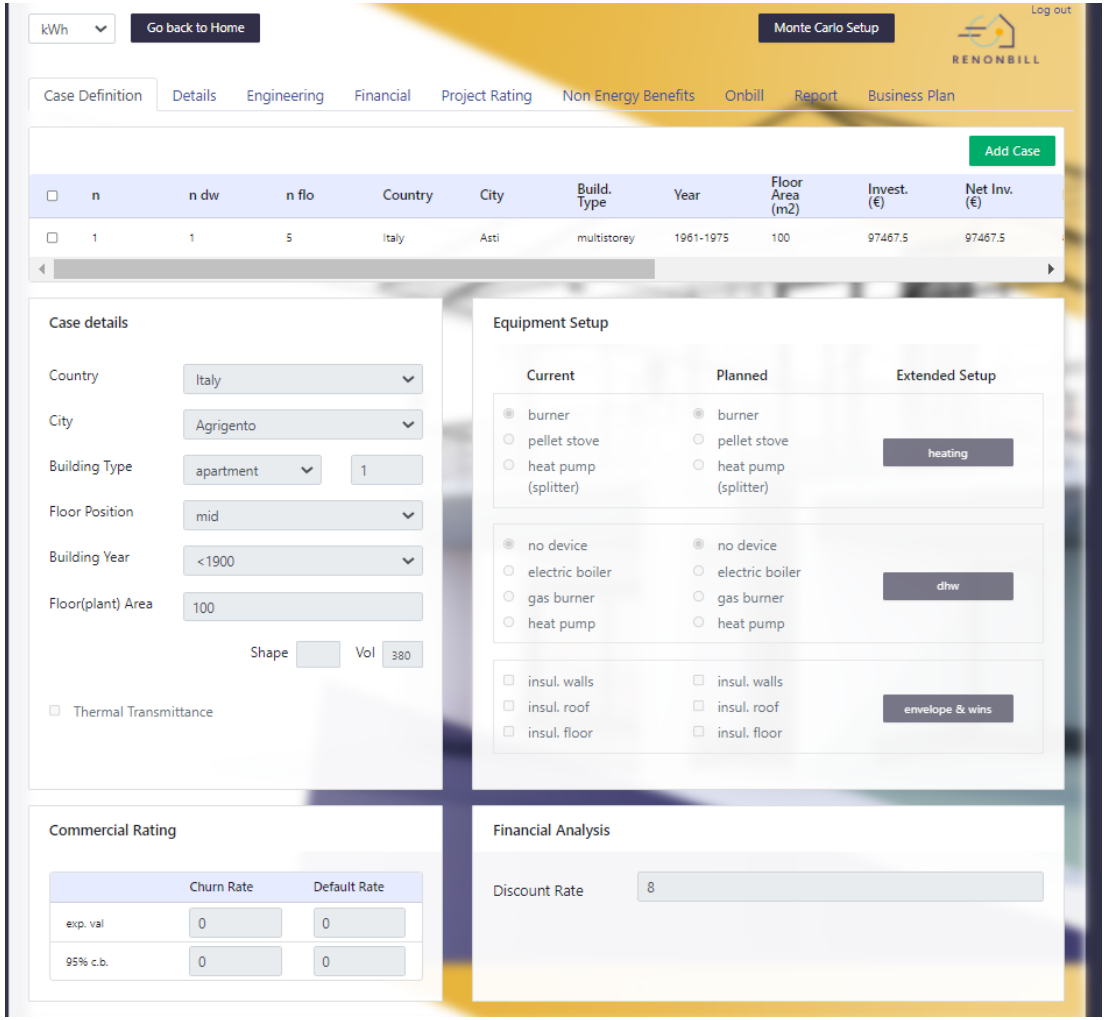
General info on the user interface

The software is organized in a series of pages of which the first is dedicated to the Case Definition.



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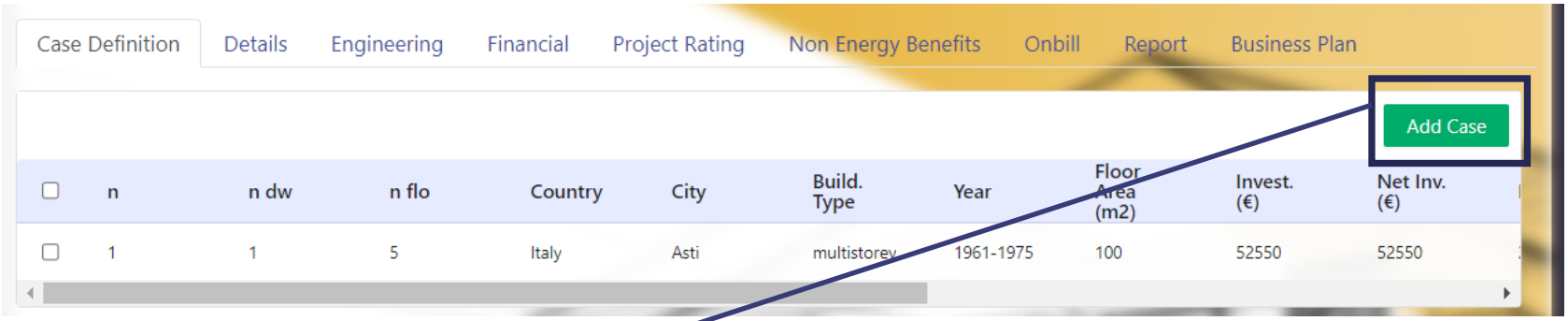
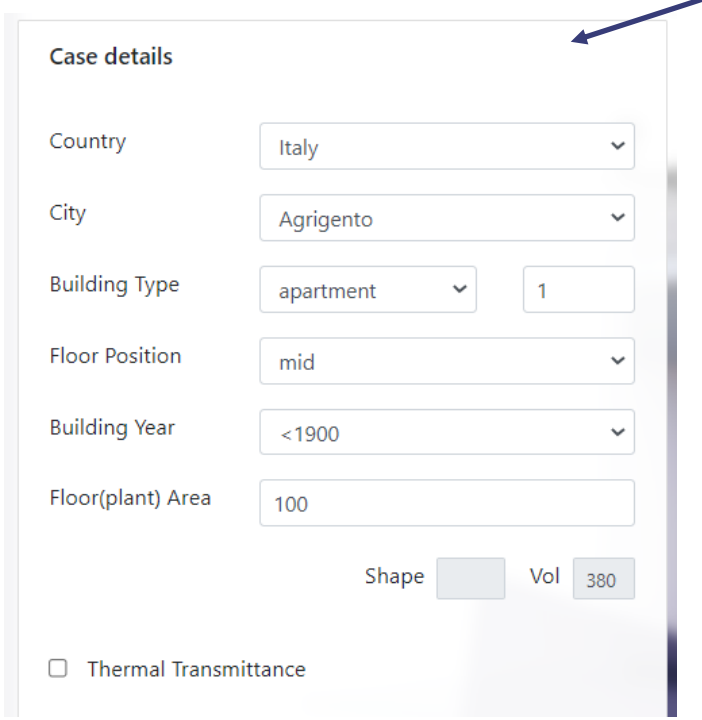
Case Definition 1/10

To add a new case click on "Add Case" and then define the feature of your case





By checking the "Thermal Transmittance" check box, it is possible to modify also two important properties: the height and the ratio between dispersing area and volume. The value of this last parameter is paramount for a correct calculation of the thermal losses. The default value is to be verified accurately since it depends on building type (e.g., n. of floors), age and location (architectural custom). Furthermore, you can define transmittance values different from those uploaded in the "Data Sheet"

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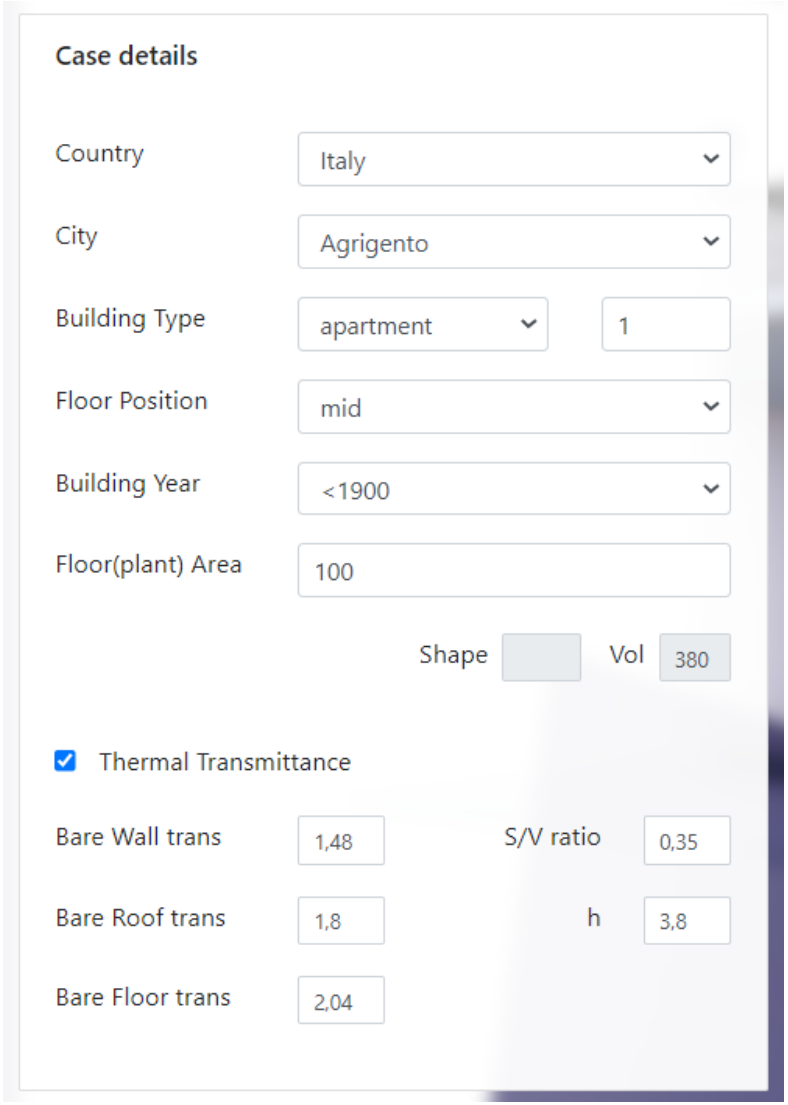
Case Definition 2/10



"Trans" stands for "Transmittance" expressed in (W/m^2*K)

h is the floor height expressed in (m)

S/V is the "surface/volume" ratio

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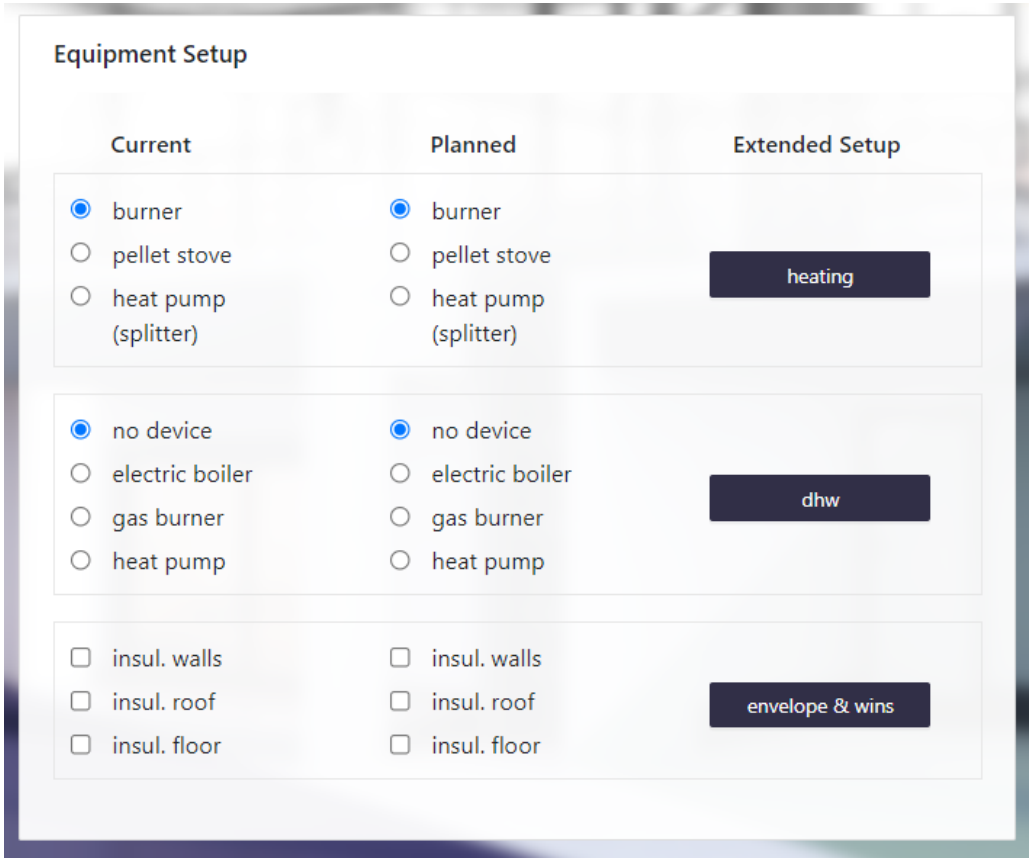
Case Definition 3/10

On the right, the area devoted to the description of the energy set-up of the existing building(s) and the choice of the renovation interventions. The set-up comprises details about the heating system (for technical details see the "Technical note" at the end of the guide), both for space heating and DHW, and about the envelope insulation, windows included.
With proper "Checkbox" choices, the current and planned, renovated equipment are defined. On the right of the fame, three push-buttons allow a more detailed set-up arrangement.



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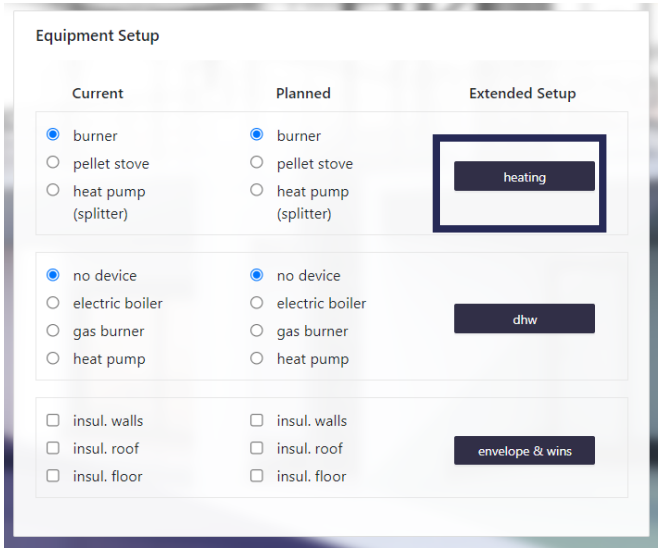
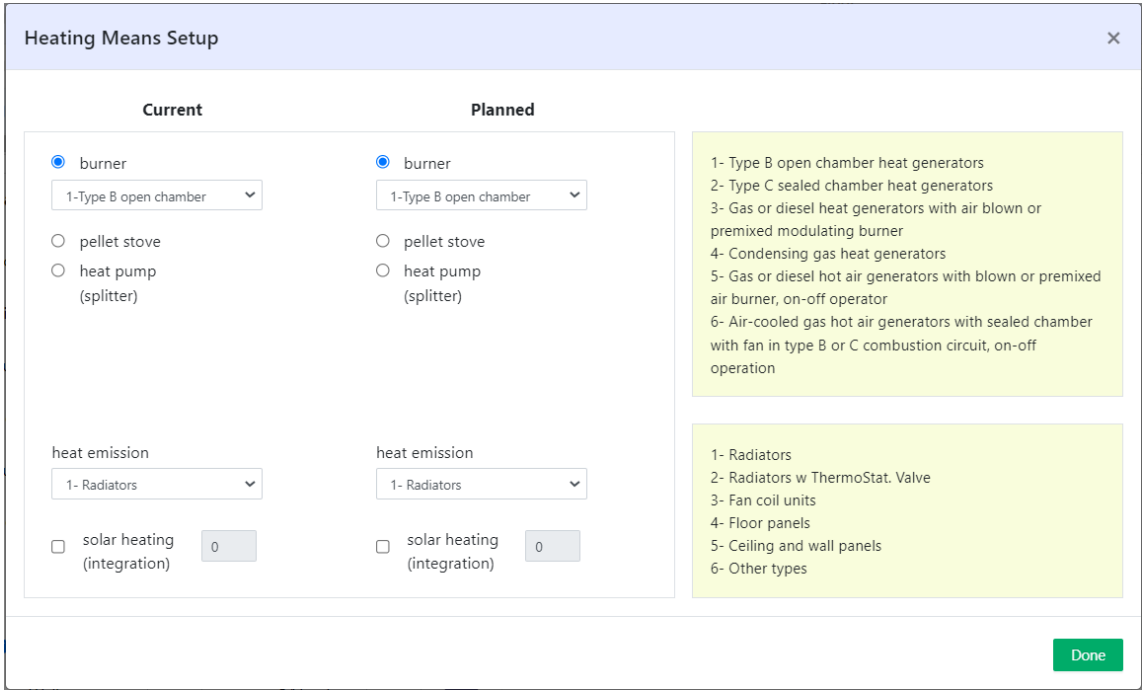
Case Definition 4/10





The "heating" button opens the form dedicated to the selection of the heating generators, the heat emitters (radiators, fan coils, etc.) and of the potential solar thermal integration.

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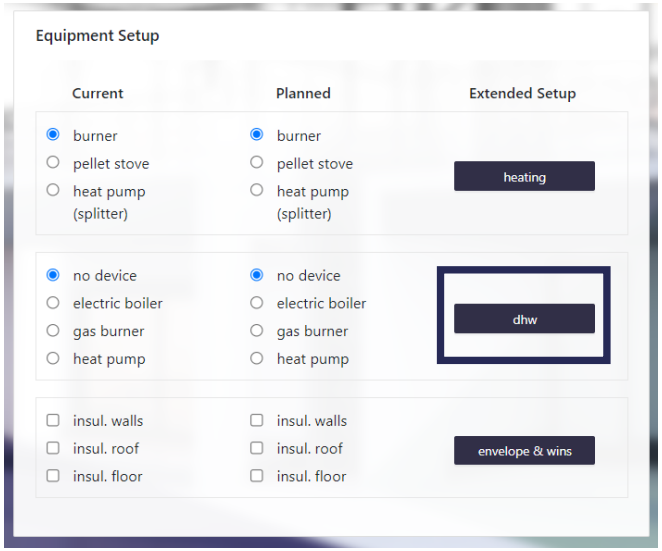
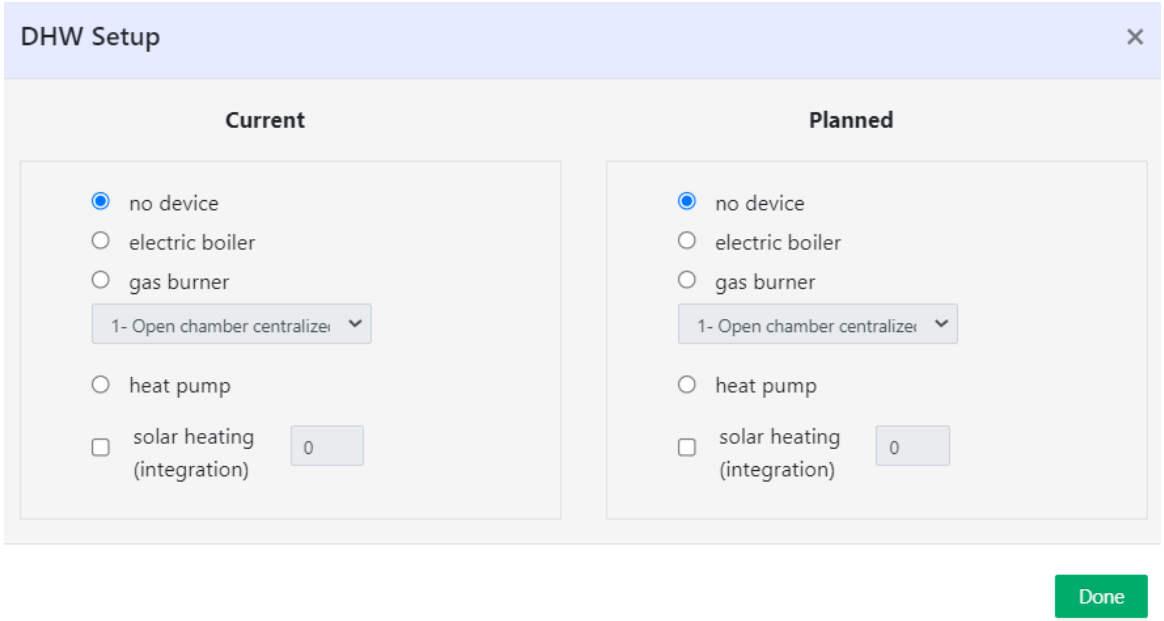
Case Definition 5/10





The "DHW" button opens the hot water generator form which, beyond the simple options present in the father frame, allows the selection of the gas burner type and the solar integration dedicated to DHW.

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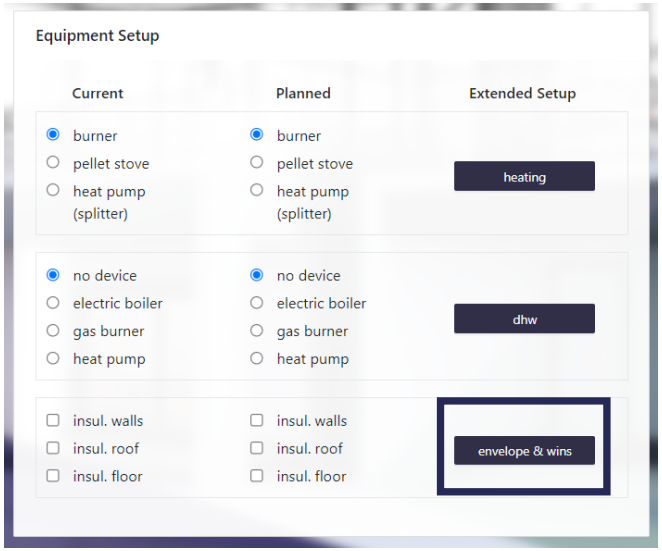
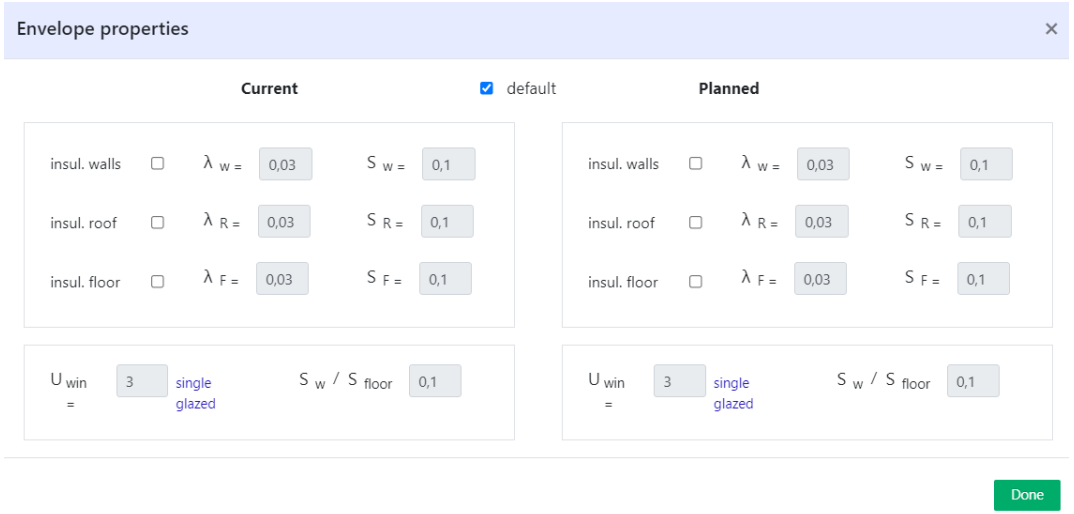
Case Definition 6/10





The "envelope &wins" button lets the user directly choose the thickness and the thermal conductivity of the wall (and roof) insulation and to explicitly provide values to the window transmittance and to the ratio between windowed and floor surfaces.

Values are independently assigned to both the current building and the planned renovated one.

Units of Measures

λ is the thermal conductivity expressed in (W/mK)

S is the thickness of the insulator expressed in (m)

U is the conductance of the windows expressed in (W/m^2*K)

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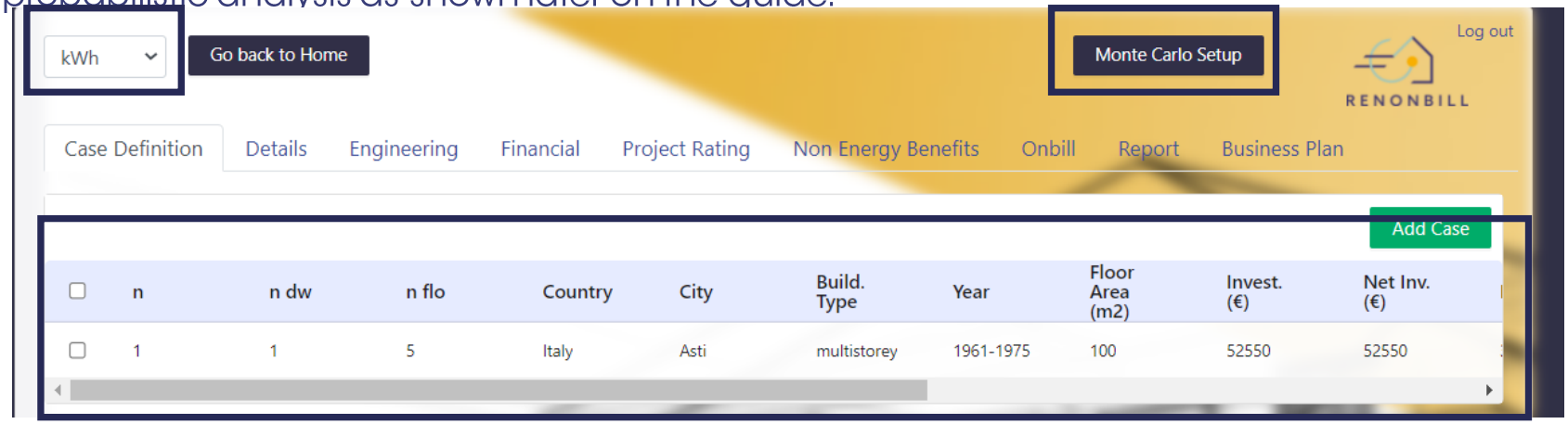
Case Definition 7/10

Once the case is defined you can see it listed and some preliminary financial calculations are immediately available. On the top left part of the screen, it is possible to change the units of measures, whereas the "Monte Carlo Setup" button allows to define the options of the probabilistic analysis as shown later-on the guide.



By clicking on the "Details" sheet a detailed summary related to energy consumption and savings will appear.

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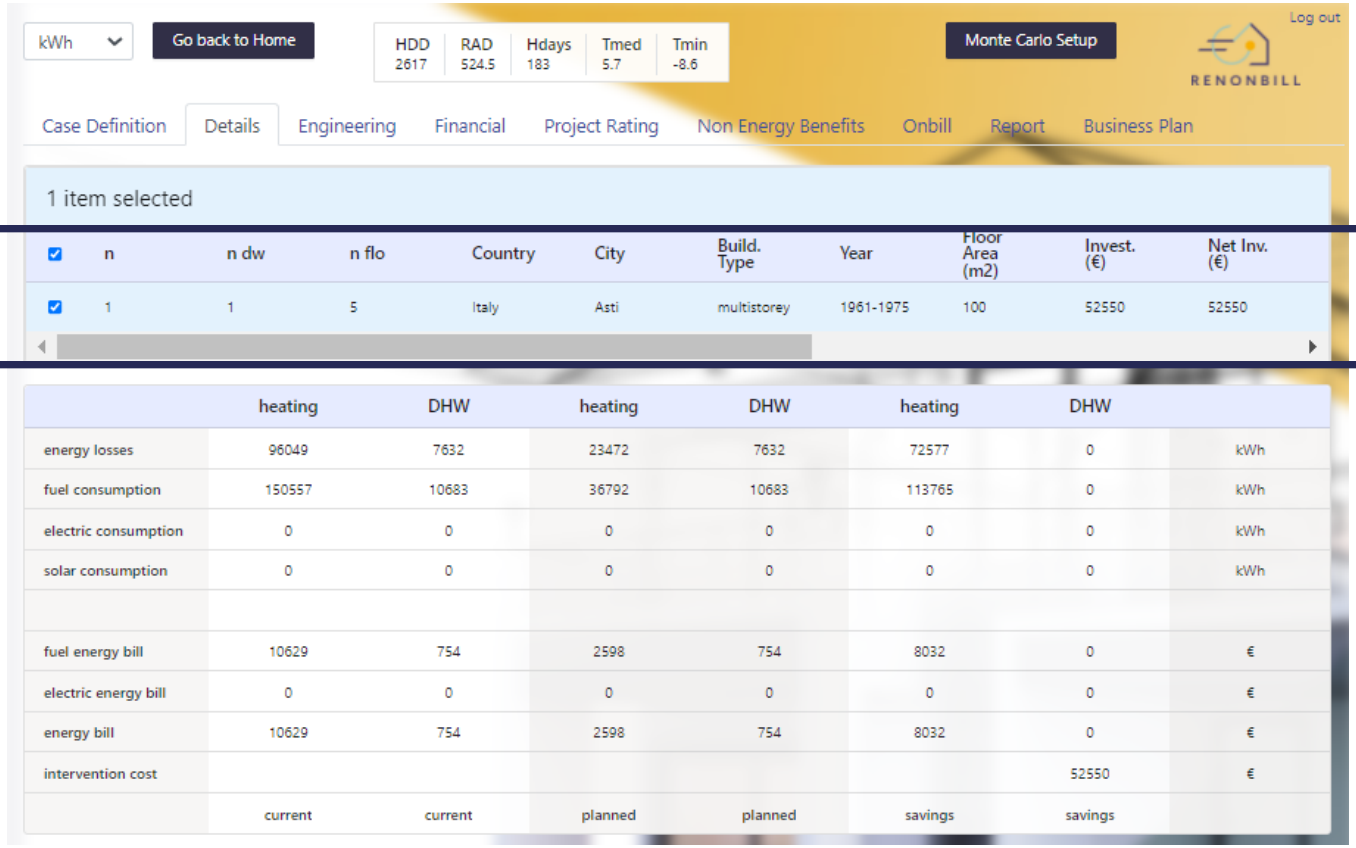
Case Definition 8/10



Once the dwelling selection is made, a quick summary of the main annual energy consumptions and the associated annual bills appear on the left part of the front page. At the top, the actual case under analysis is highlighted along with its Country, city, apartment type and other resume data. Below, the energy dispersion is provided along with the various energy components: fuel (fossil), electric, solar, primary according to the considered case. Values are reported for both the current and the planned configuration (the difference is the savings). Energy values are related to the heating season.

Further down, the amounts of the corresponding annual bills and bill savings are shown.

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Case Definition 9/10

	current	planned	difference	
Ewall = outward heat transfer (external walls)	66374	9666	56707	kWh
Ewin = heat transfer across windows (conduction/convection)	17900	17900	0	kWh
Efloor = heat transfer through the floor	8165	1531	6634	kWh
Eroof = heat transfer through the roof	10733	1498	9236	kWh
Ev = heat transfer due to ventilation (air exchange)	7904	7904	0	kWh
Eis = internal heat source due to persons and equipment	-7411	-7411	0	kWh
Eswin = solar radiation across the windows	-7615	-7615	0	kWh
Heating				
Ed = needed thermal energy	96049	23472	72577	kWh
Ef = consumed fuel energy	150557	36792	113765	kWh
Eel = consumed electric energy	0	0	0	kWh
Hot water				
DHW Ed = needed thermal energy	7632	7632	0	kWh
DHW Ef = consumed fuel energy	10683	10683	0	kWh
DHW Eel = consumed electric energy	0	0	0	kWh

Furthermore, more detailed data are available regarding the energy dispersion contributions from dispersing surfaces. As before, data are reported for both the current and the planned configuration. Energy dispersions are detailed by giving the energy losses through walls, roof, floor, windows and the contribution due to ventilation, internal energy sources and collected solar energy. Again, these results can be shown for a selected dwelling or all the considered dwellings.

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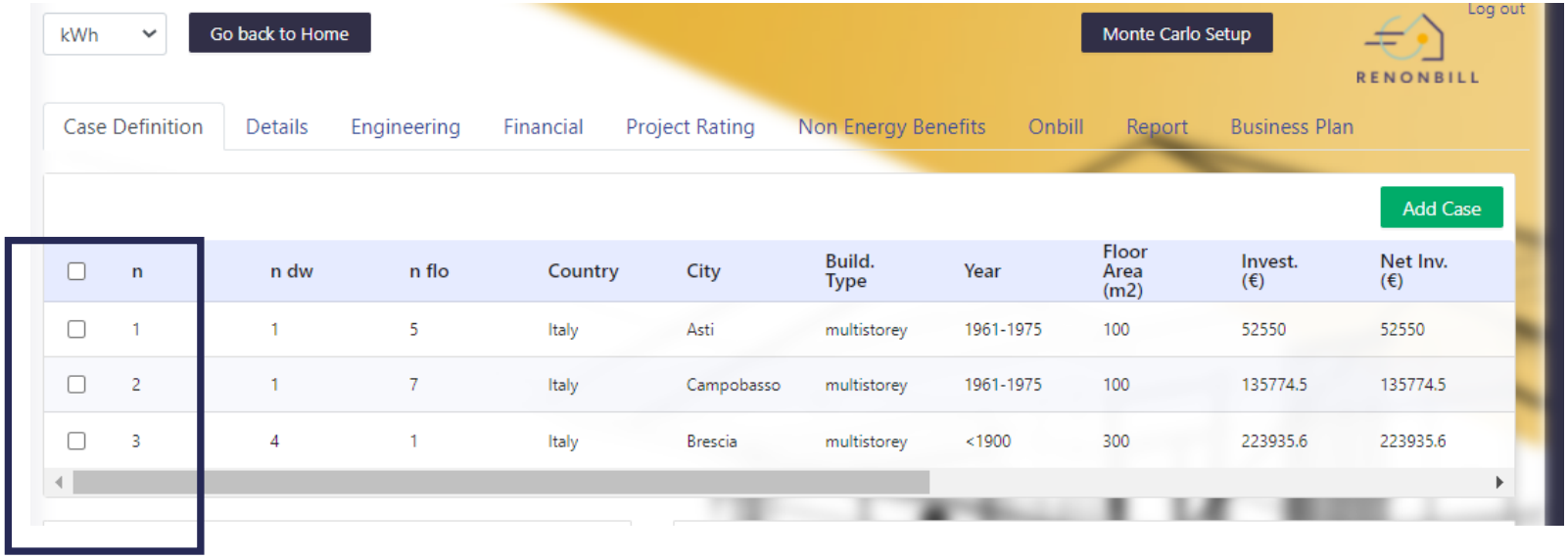
Case Definition 10/10

The summary, and in general the whole analysis, can refer to either the selected dwellings (multi-selection allowed) and the whole set of cases (if nothing is selected).



n	n dw	n flo	Country	City	Build. Type	Year	Floor Area (m2)	Invest. (€)	Net Inv. (€)
1	1	5	Italy	Asti	multistorey	1961-1975	100	52550	52550
2	1	7	Italy	Campobasso	multistorey	1961-1975	100	135774.5	135774.5
3	4	1	Italy	Brescia	multistorey	<1900	300	223935.6	223935.6

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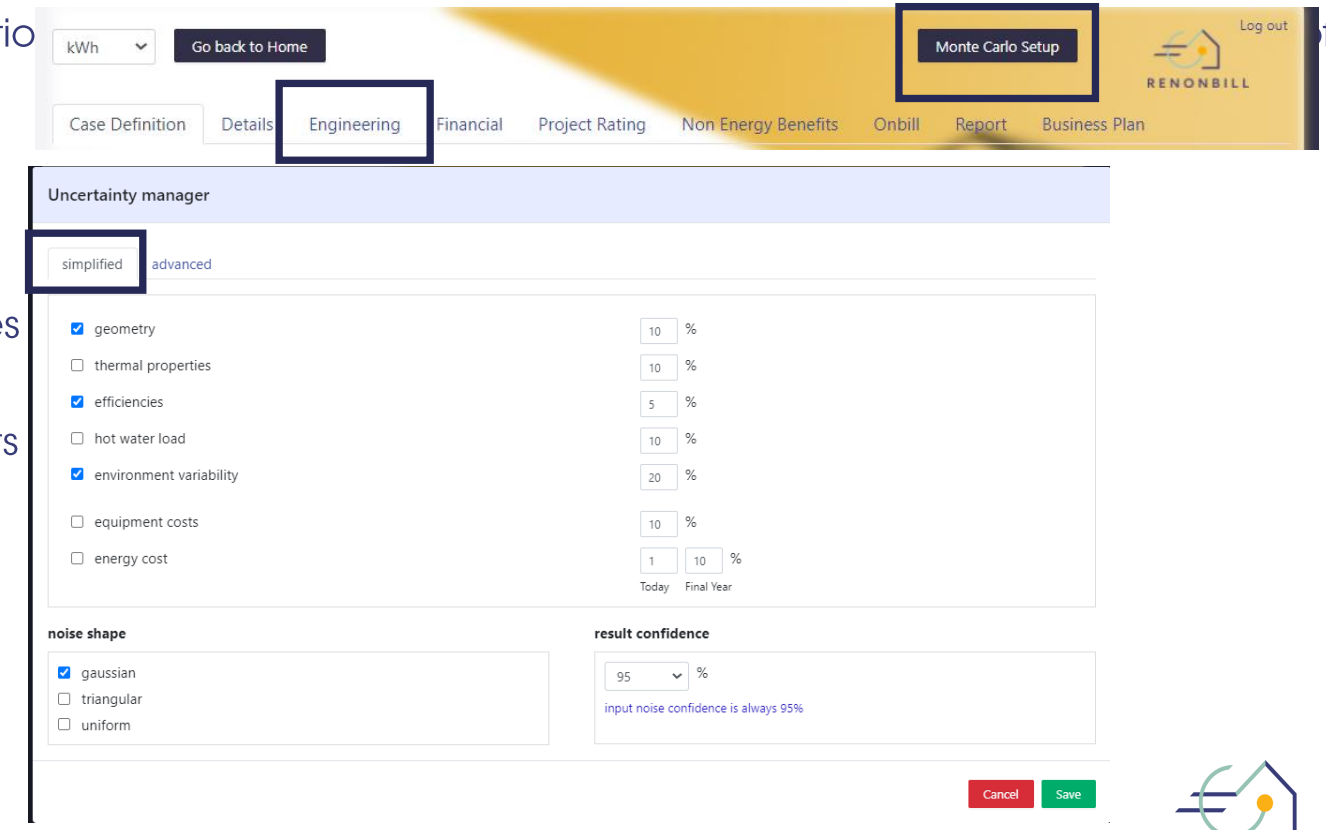
Engineering analysis 1/5

To run the engineering analysis, it is necessary to set-up the Monte Carlo simulation by defining the level of uncertainty by clicking on the "Monte Carlo" set-up button.

The choice of the std. dev. of the noise superposed to key variables (95% confidence bounds) is performed through the following form which allows setting the shape of the noise (normal, triangular, or uniform) and the confidence level used to calculate and present the uncertainty associated to the Monte Carlo results (99%,95%,68%,50%). A double level of control is possible by checking the proper optio f variables, specifically

- geometric variables
- Thermal properties
- Device efficiencies
- Environment variables
- DHW requirements
- Equipment fixed costs
- Energy cost



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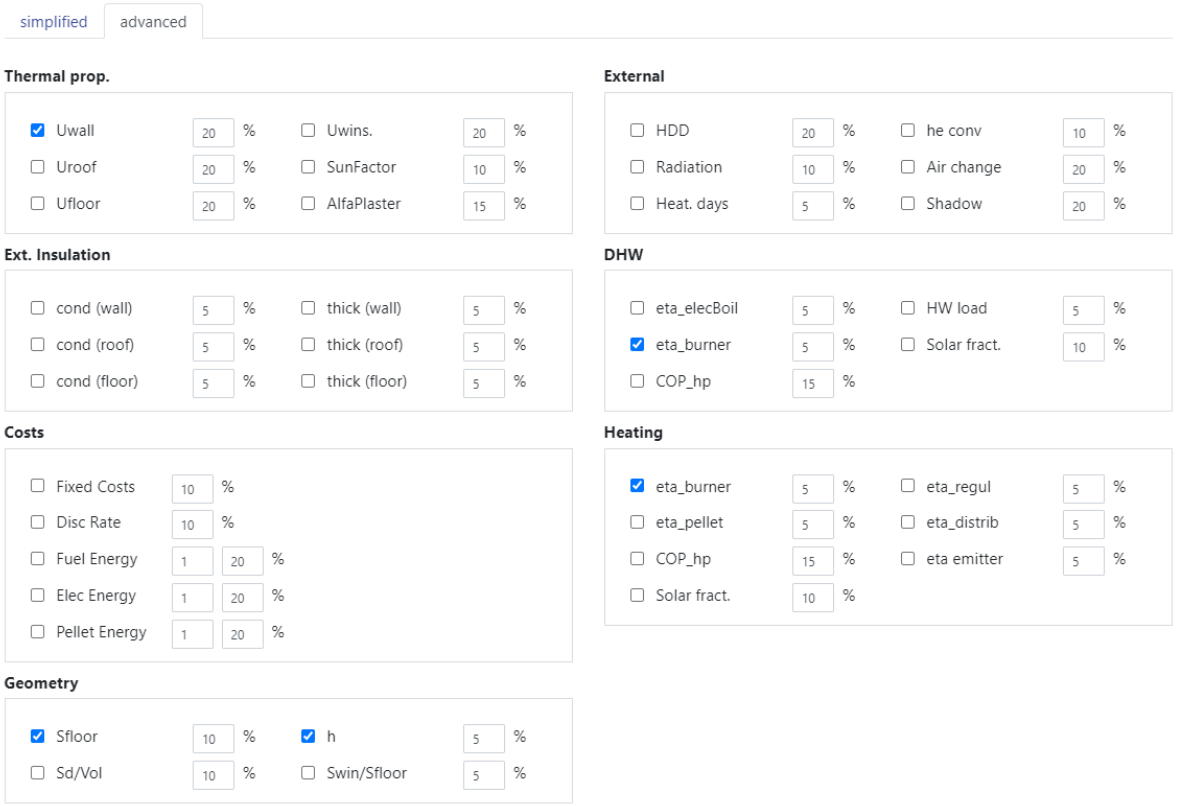
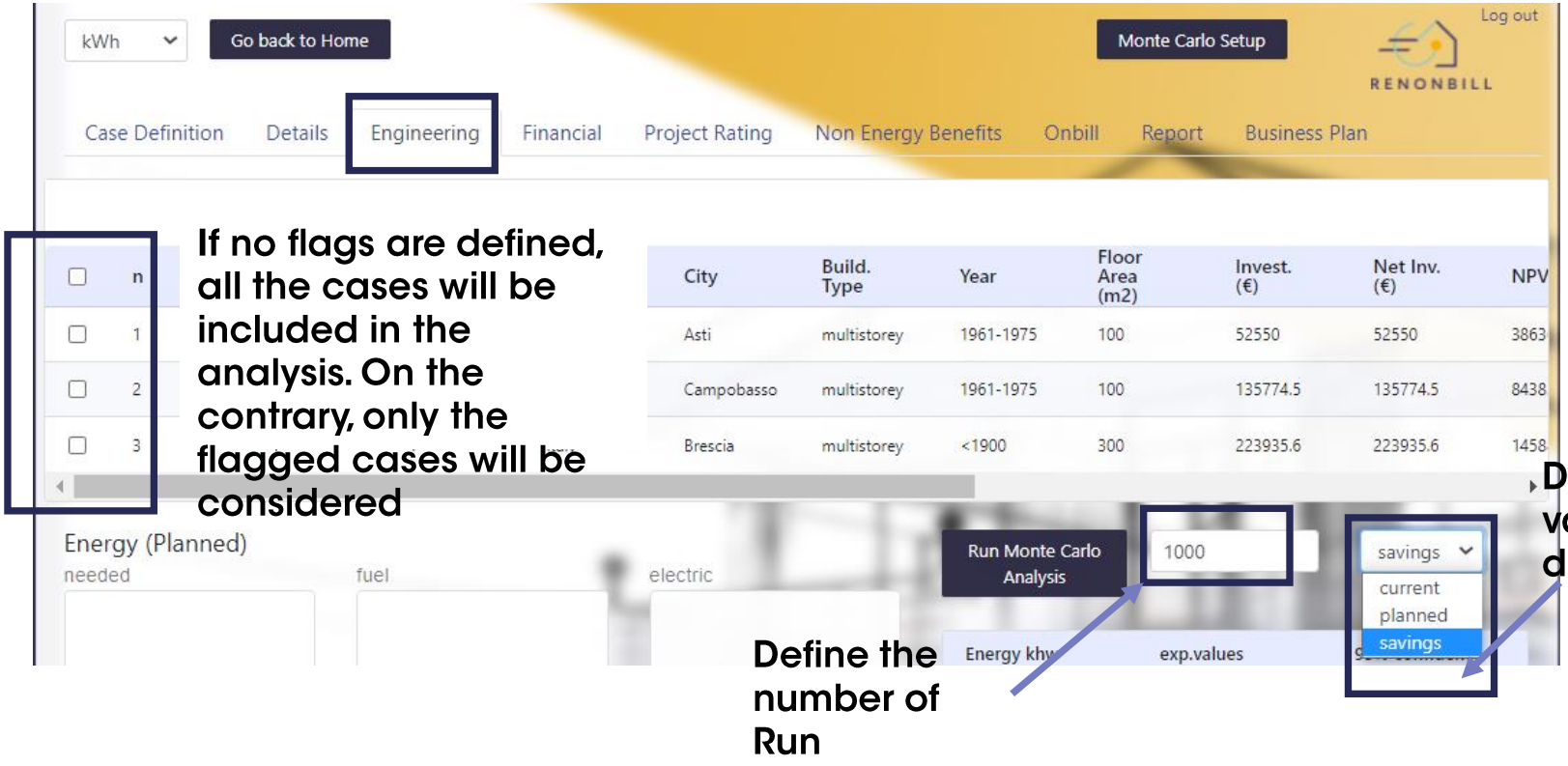
Engineering analysis 2/5



To gain a more refined control of the uncertainty, the advanced check is selected and, on the resulting extended form, each variable group is articulated in its components as shown in the figure.

By checking the variables of interest and setting their uncertainty (95%C.B.) expressed as a percentage of the variable value, a deep analysis can be done on the expected values of the energy and economic indices and their volatility. Very accurate investment risk analysis can be performed and the importance, to this respect, of the considered variable can be properly appraised.

Engineering analysis 3/5



If no flags are defined, all the cases will be included in the analysis. On the contrary, only the flagged cases will be considered

Define the variable to display

Define the number of Run

The second page, named Engineering Analysis, is dedicated to the Monte Carlo method setup and analysis. As known, the Monte Carlo analysis is a simple though powerful technique to analyse the behavior of a system under an uncertain regime. The energy or economic analysis is repeated a great number of times by using perturbed values of the selected relevant variables to investigate how their uncertainty propagates to the calculated performance indices.

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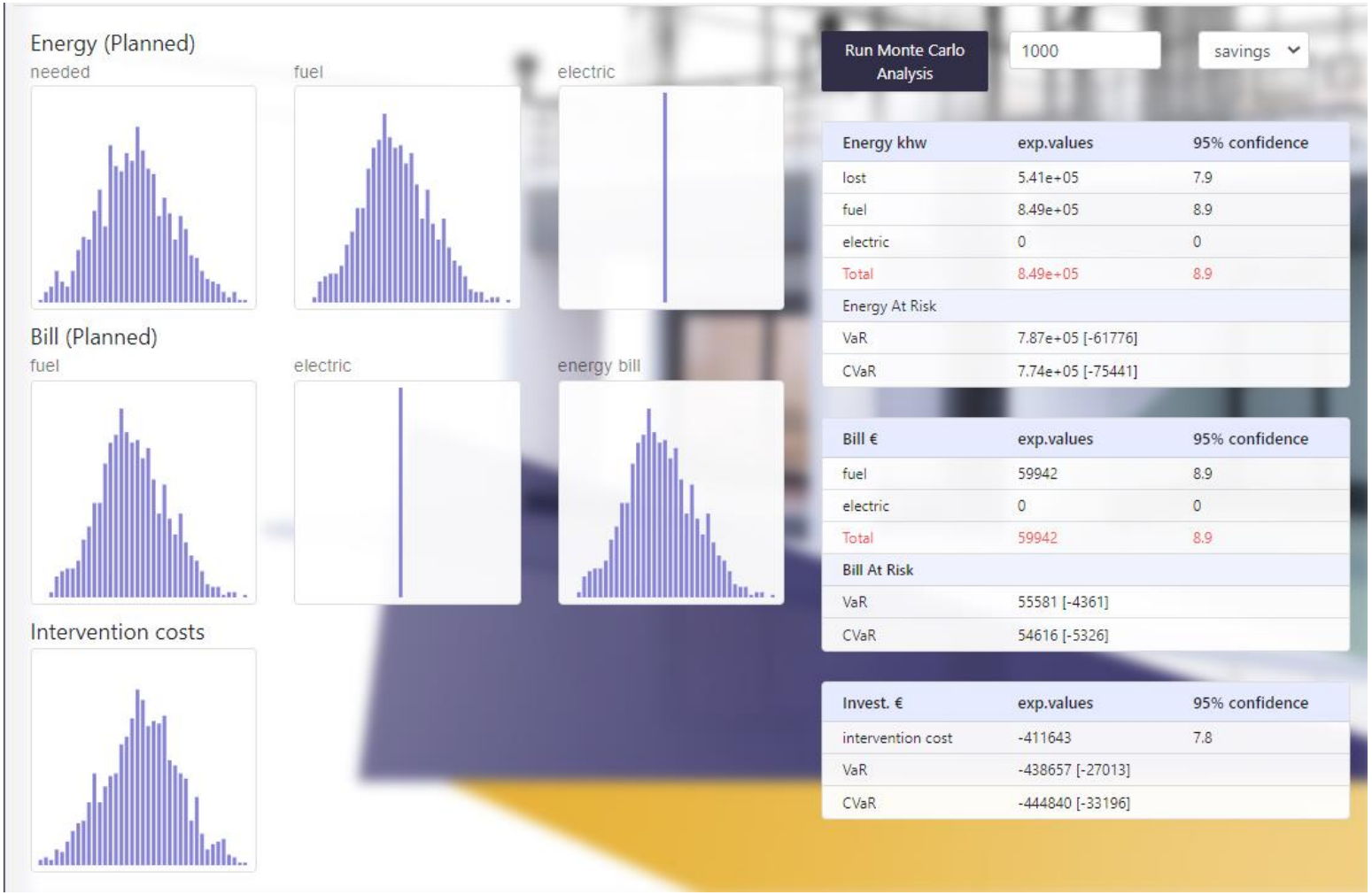
Engineering analysis 4/5

Probabilistic distribution of energy variables (energy consumption in the "current" or "planned" case or "energy savings") and intervention cost.



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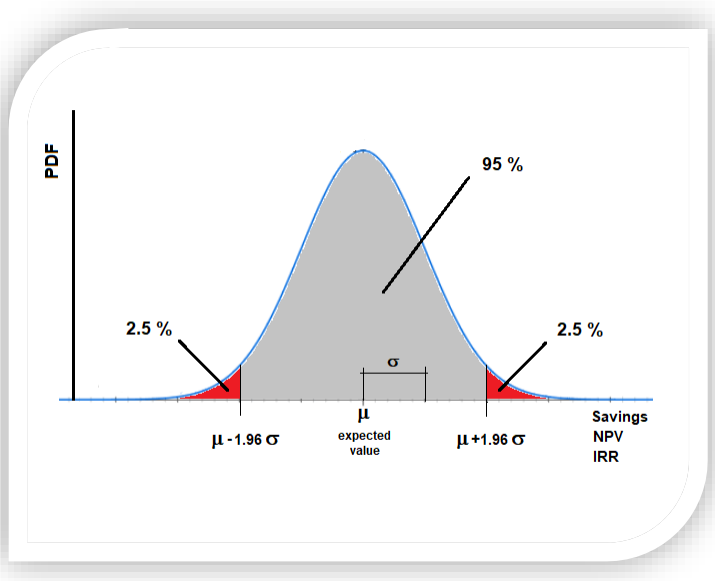
Engineering analysis 5/5

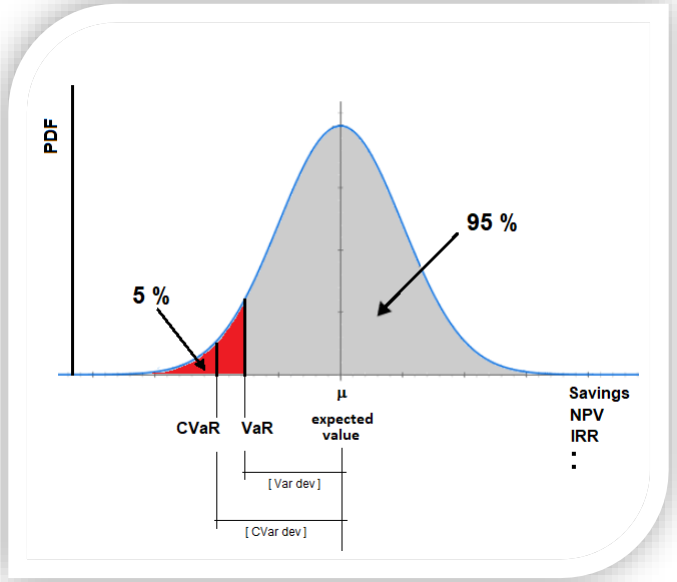
From the analysis, two types of results emerge:

- Expected values with associated confidence
- Values at Risk, VaR, and Conditional Values at Risk, CVar

The difference between the C.B. and the "at-risk" analyses is summarized in the following two figures.

PDF: Probability Density Function





On the left the usual confidence region and the out-of-boundaries red regions. On the right, instead, the focus is on the red "at risk" region, referring to undesired results (5%) and their conditional expectation, CVar, that is the mean value of the red region.

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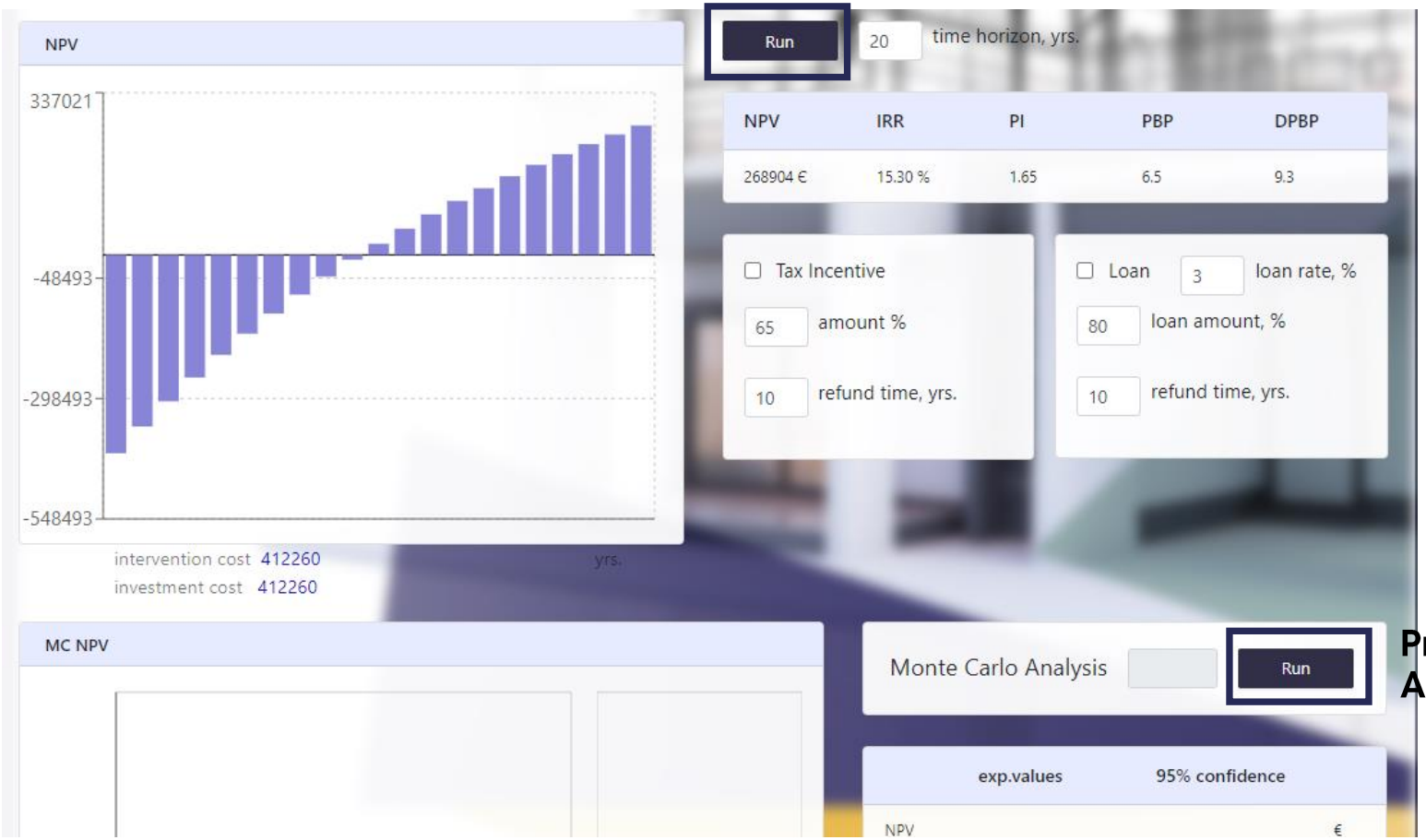
Financial analysis 1/4

The third page performs the *Financial Analysis*. Deterministic and stochastic investigations are carried out separately using dedicated buttons.

Deterministic Analysis



Probabilistic Analysis

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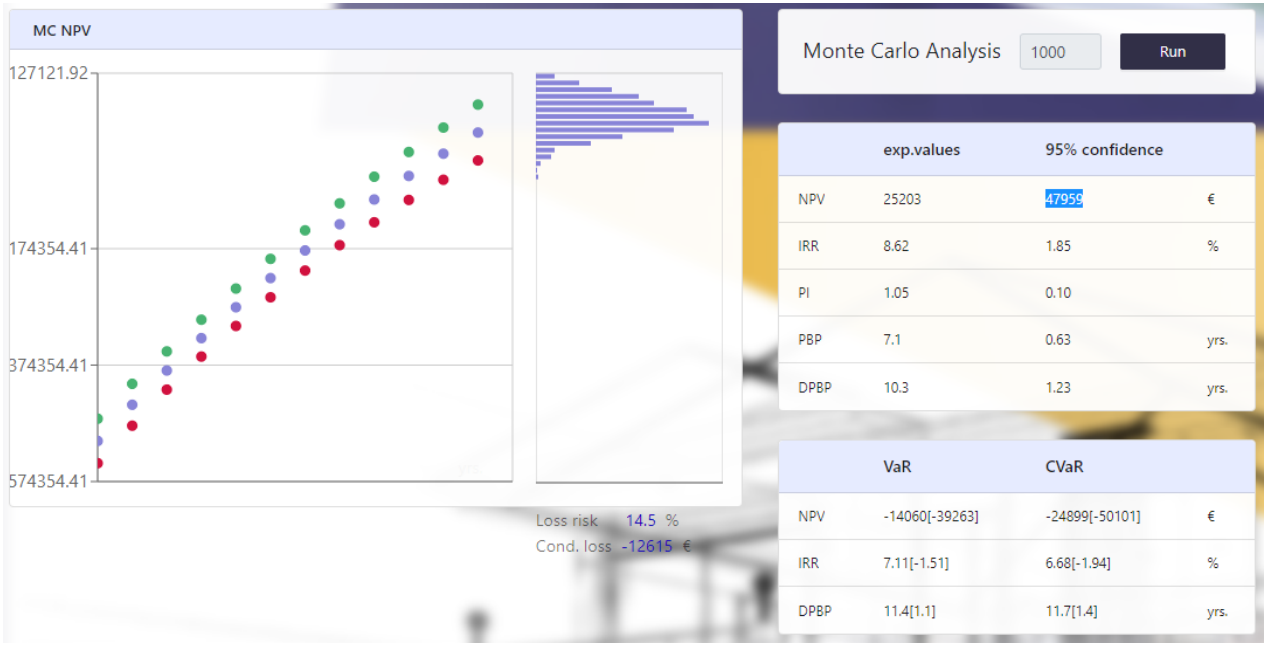
Financial analysis 2/4



The main economic indices related to the intervention are evaluated: Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Pay Back Period (NPV) and Discounted Pay Back (DPBP). Their stochastic counterparts are evaluated too along with the associated confidence bounds. Value at Risk (VaR) and Conditional Value at Risk (CVaR) are present only in the Monte Carlo, stochastic section.

The above Figure reports from a simple analysis: on the left, a standard NPV diagram can be observed. In the considered example a small gain margin is calculated corresponding to a time horizon of 11 years. The graph on the left is obtained under an uncertain regime. It results from 1000 different run. In the considered case, despite the positive NPV, the probability of total loss in around 14.5%. VaR and CVaR are negative. The locations considered have a too warm climate to fully justify the intervention (envelope insulation, in this case).

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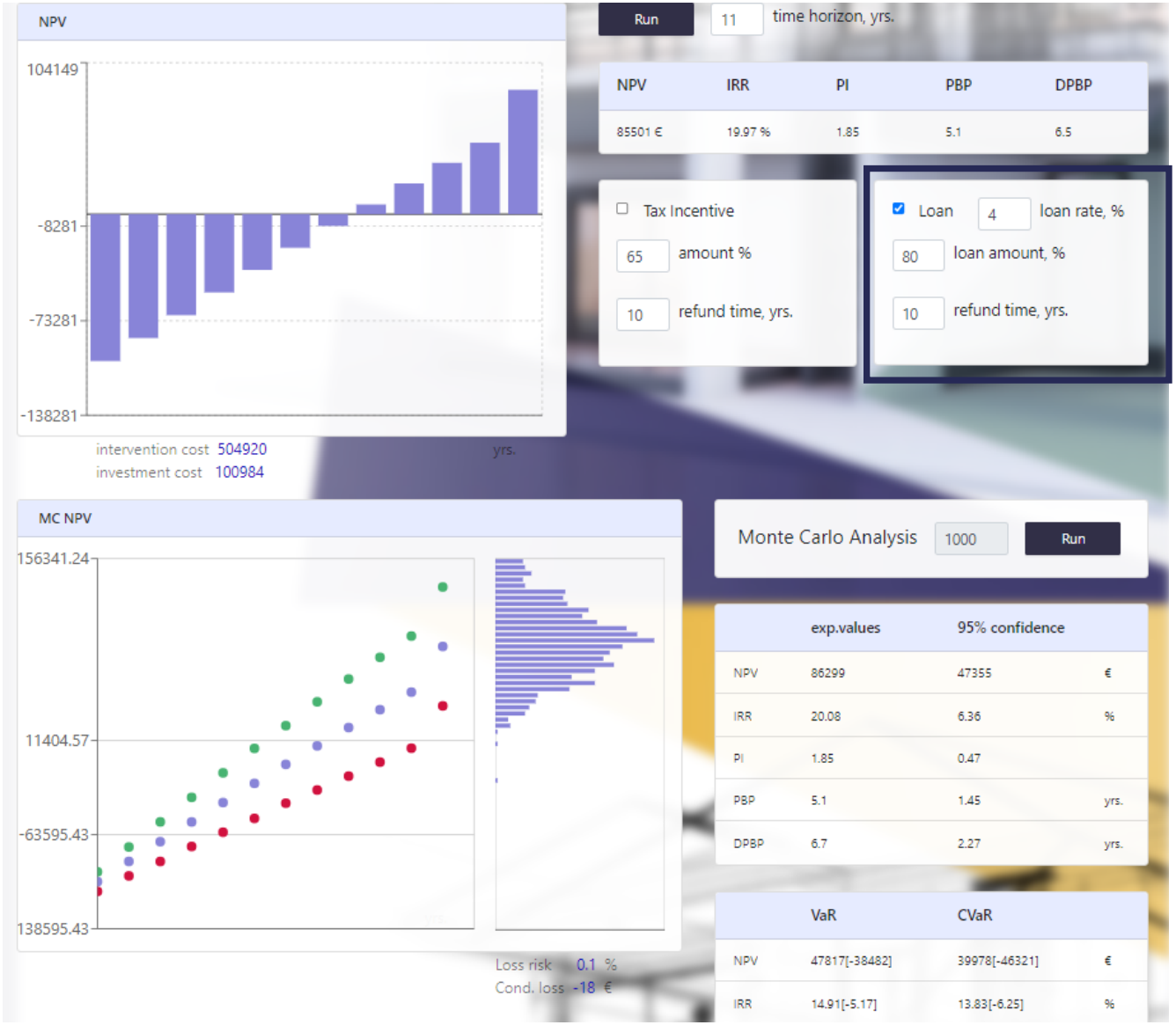
Financial analysis 3/4



A different picture emerges if the investment costs are covered by a loan. In this case, a better performance of the investment can be achieved as per the following figure.

It is also possible to define tax incentives.

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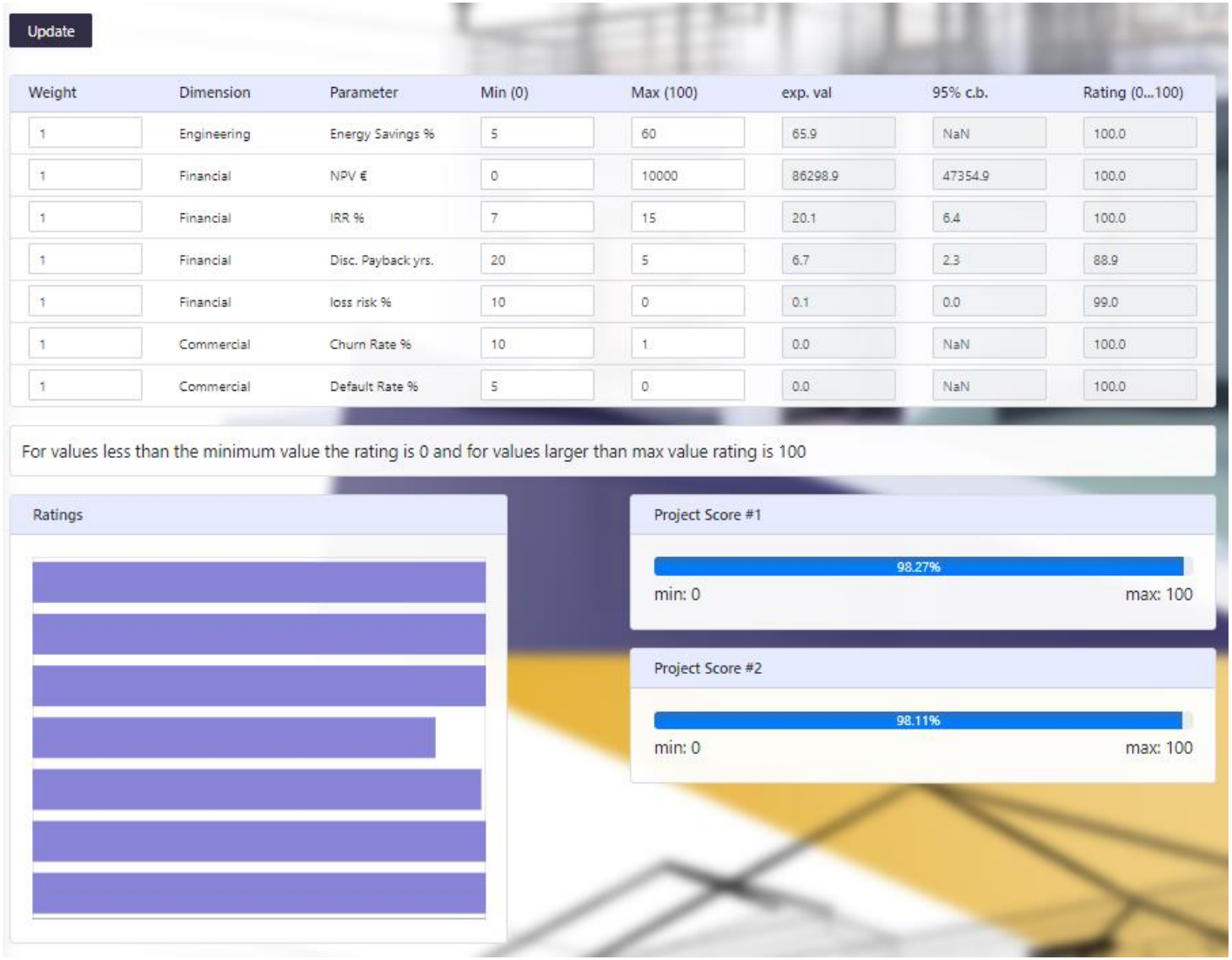
Project Rating 1/3



The 5th page, ***Project Rating***, provides the overall score of the project by mixing results from the previous analyses to commercial indices manually introduced by the user.

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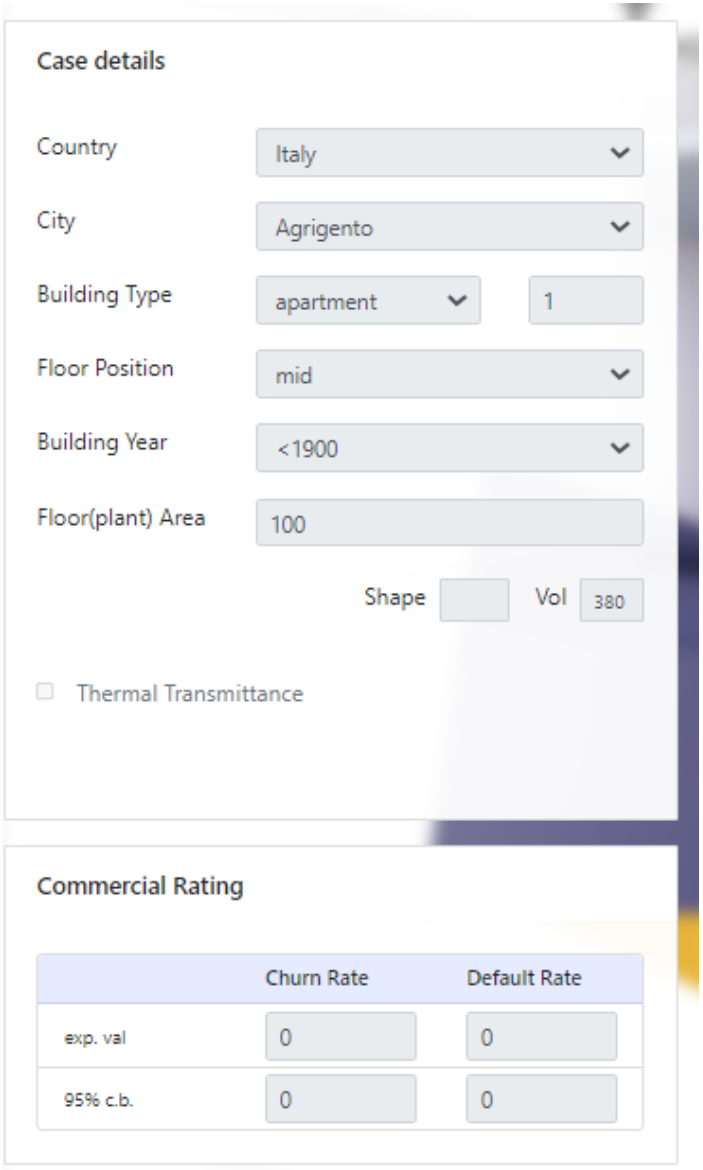
Project Rating 2/3



Currently, seven indices are considered, properly weighted, to form the project rating. Five of them: Energy Savings (ES), NPV, IRR, Payback time and loss Risk, are available from the previous phases of the analysis. If present, their Monte Carlo estimated values are used, otherwise, the deterministic counterparts are utilized.

The other two indices account for the solidity of the client by quantification of its commercial relationship with the energy utility; the client's default rate in paying energy bills, and the client's loyalty to the utility quantified by the churn rate. These parameters are up to the user which also discretionary sets the index variability range at his discretion by providing a maximum and a minimum value. They can be set in the Case Definition section within the **Commercial Rating section** which allows the user to quantify both churn and default rates for each client or a selected set of clients.

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Project Rating 3/3

Two different overall scores are presented. The first, Project Score #1, is simply a linear combination of the seven Ratings (Ri), that is

$$S_1 = 100 \frac{\sum_i W_i \cdot R_i}{\sum_i W_i}$$

with Ri the ratings and Wi their weights

While the second score, Project Score #2, is defined as

$$S_2 = 100 \left[\frac{\sum_i W_i \cdot (R_i)^{-1}}{\sum_i W_i} \right]^{-1}$$

and stresses the critical issues emerging from single Ri values; if even just one Ri tends to zero, the overall Score #2 tends to zero too.

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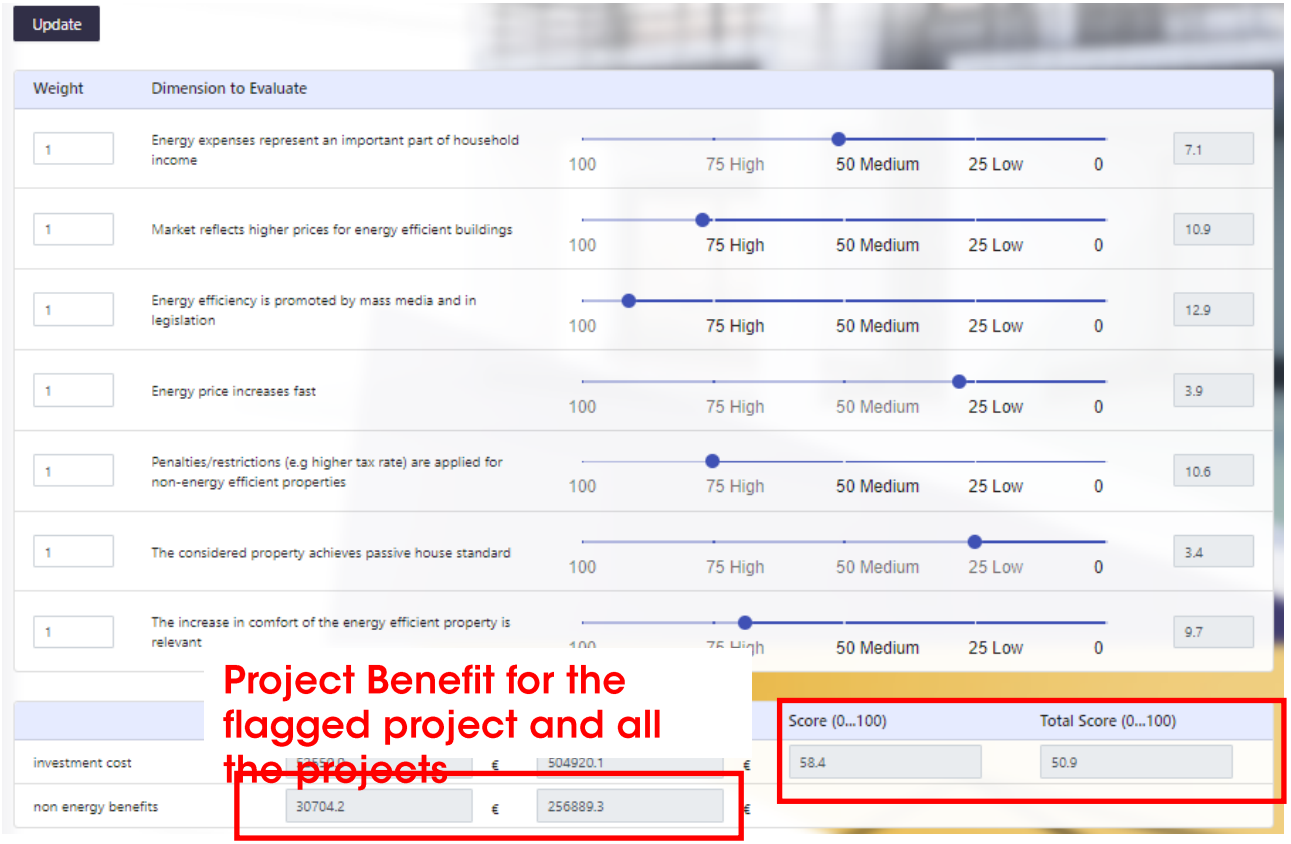
Non-Energy Benefits 1/2

The fifth page is devoted to the quantification of "non energy benefits". Currently, it assumes that the maximum value (benefit) that can be added to a property as a result of the renovation is a quota (from 0 to 100%) of the value of the investment performed in energy efficiency interventions. A higher value, i.e. higher than 100%, would be irrational, because one could buy a non-refurbished property and retrofit it, to obtain the same level of benefits at a lower cost.



Project Benefit for the flagged project and all the projects

Project Score for the flagged project and all the projects

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Non-Energy Benefits 2/2

This section of the tool is not linked to previous analyses.
The quantification of the benefit is subjective. A series of potential benefits are presented to the user which, who based on its experience and sensibility will assign:

1) an importance weight to each benefit to evaluate and,
2) for each benefit, the rank, between 0 and 1, of the considered (selected) dwelling.

Input data are then summed and normalized to give a score, in the interval 0-100, visible at the bottom right of the form. Single scores are composed to form a total score of the project that represents the ratio between the added value and the total investment. Multi-selection is allowed too.

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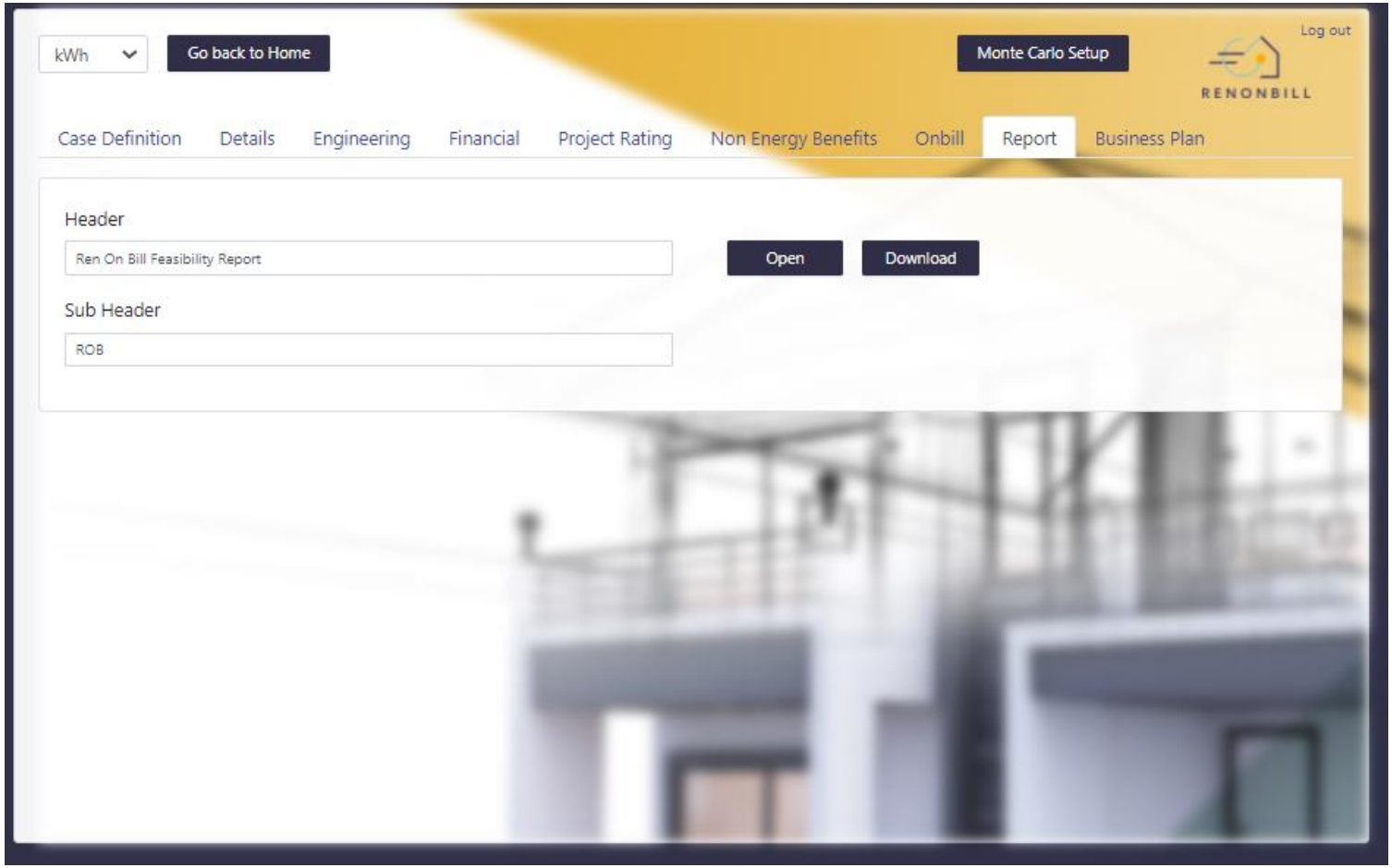
Reporting 1/2

Finally, the "Report" page is devoted to reporting. Report always refers to the whole project. It always include engineering & financial, project rating and non-energy benefits results.



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Reporting 2/2

Example of "Sheet Report"

Summary of Intervention

Ren On Bill Feasibility Report

ROB

Country	Italy
num of dwellings	7
total surface, m2	4900

Investment

	amount	amount%	refund time yrs.	rate%
Intervention cost	504920.1			
Loan	403936.1	80	10	4
Tax Incentive	-0.0	0	10	
Initial Investment	100984.0			

Financial

Time horizon	Initial	NPV, €	IRR	PI	DPB, yrs.
11	100984.0	86298.9	0.2	1.8	6.5

Project Rating

	Weights	Min	Max	Values	Confidence	Ratings
Energy Savings, %	1	5	60	0.7	0.0	100.0
NPV, €	1	0	10000	86298.9	0.0	100.0
IRR, %	1	7	15	0.2	0.1	100.0
Disc. PayBack, yrs.	1	20	5	6.7	2.3	88.9
Loss Risk, %	1	10	0	0.0	0	99.0
Churn Rate, %	1	10	1	0.0	0.0	100.0
Default Rate, %	1	5	0	0.0	0.0	100.0

98.27 Score #1
98.11 Score #2

Energy Analysis

	Fuel Energy consumption, kWh	Electric Energy consumption, kWh	Fuel Energy Bill, €	Electric Energy Bill, €	Energy consumption, kWh	Energy Bill, €	Heating Energy losses, kWh	DHW Energy losses, kWh	Energy losses, kWh
current	1438655.9	0.0	123811.9	0.0	1438655.9	123811.9	851012.7	74795.1	925807.8
planned	490491.2	0.0	42212.1	0.0	490491.2	42212.1	246121.7	74795.1	320916.8
savings	948164.7	0.0	81599.9	0.0	948164.7	81599.9	604891.0	0.0	604891.0

Monte Carlo & Risk Analysis

	Energy Savings	Bill Savings	Intervention Costs	NPV	IRR	DPBP
Value	959249.2	67722.9	504893.2	86298.9	20.1	6.7
99% Confidence Bou	100479.3	7093.8	38546.2	47354.9	6.4	2.3
Value at Risk	875166.2	61786.6	537210.1	47817.2	14.9	8.8
Conditional Value at I	852462.9	60183.8	546520.0	39978.0	13.8	9.3

Non Energy Benefits

score	benefits
0.5	256889.3

year	NPV	MC_NPV	CB+	CB-
0	-100984.0	-101035.9		
1	-85173.0	-84944.4	-74259.4	-97294.8
2	-69433.8	-69200.3	-53345.1	-84887.7
3	-53815.9	-53476.6	-33471.3	-72547.5
4	-38362.2	-38032.0	-13362.1	-60683.9
5	-23109.7	-22775.2	6408.6	-49369.4
6	-8089.9	-7645.2	24630.1	-37146.4
7	6670.1	7088.8	44753.8	-25523.6
8	21147.9	21692.7	63383.8	-13981.7
9	35324.8	35911.5	80733.1	-2724.3
10	49185.5	49917.5	97274.4	7977.2
11	85500.8	86298.9	136332.1	41622.4

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Data Sheet 1/7

To perform the thermal and financial analyses, some data is required about

- Climatic conditions of a set of European cities in terms of Heating Degree Days (HDD), solar radiation, mandatory or suggested dates for switching on and off the heating system
- Building information regarding the type of construction, its age and its main geometric and thermal characteristics
- Heating system device efficiencies
- Investment costs and energy variable costs

All this data are available in the file "tools_default_data.xlsx". This file represents the default data and it must not be renamed.

You can create a copy of it and rename as you want to create other data sets to be uploaded as "User Data File" (see chart n. 10).

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Data Sheet 2/7

A shot of the first sheet "City Climate" is reported below.

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Country**	**City**	**HDD**	**zone**	**heating on/off**			**average daily Solar rad [MJ/m^2] South vert. Wall**	**January**	**February**	**March**	**April**
2	Italy	Agrigento	729	B	01.12/31.03				13,8	15,4	14,4	12
3	Italy	Alessandria	2559	E	15.10/15.04				8,4	10,2	11,1	10
4	Italy	Ancona	1688	D	01.11/15.04				6,6	9,7	11,3	11
5	Italy	Aosta	2850	E	15.10/15.04				10,3	11,6	12,1	10
6	Italy	Arezzo	2104	E	15.10/15.04				8,6	9,7	10,2	9
7	Italy	Ascoli Piceno	1698	D	01.11/15.04				8,8	10,4	11,6	10
8	Italy	Asti	2617	E	15.10/15.04				9,4	10,9	11,6	10
9	Italy	Avellino	1742	D	01.11/15.04				8	10,1	11,1	10
10	Italy	Bari	1185	C	15.11/31.03				10,9	13,3	13,2	12
11	Italy	Belluno	3001	F	01.09/30.05				7,8	10,7	11,9	10
12	Italy	Benevento	1316	C	15.11/31.03				8,8	10,7	11,4	10
13	Italy	Bergamo	2533	E	15.10/15.04				7,3	9,3	11	10
14	Italy	Bologna	2259	E	15.10/15.04				7,4	10,7	11,6	11
15	Italy	Bolzano	2791	E	15.10/15.04				8,5	12,5	13,1	11
16	Italy	Brescia	2410	E	15.10/15.04				8,2	11	12,3	10

Each row refers to a city. Its climatic features are described by a set of parameters

Values are user-modifiable, and rows can be added to the sheets with the only rule of not to mix different countries. Further countries can be added as blocks of rows.

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Data Sheet 3/7

The second sheet, "Thermal Data", is dedicated to building information. The data currently available in the tool are taken from the Tabula IEE Project

	1	2	3	4	5	6	7	8	9	10
1	country	building type	age	Wall thermal transmittance [W/(m2K)	Roof thermal transmittance [W/(m2K)	Floor thermal transmittance [W/(m2K)	S disp/V	Windows thermal transmittance [W/(m2K)	Swin/Sfloor	height
57	Spain	Multistorey	<1900	2,63	3,08	1,92	0,42	2,4	0,095	3,80
58	Spain	Multistorey	1901-1920	2,63	3,08	1,68	0,19	5,7	0,095	3,80
59	Spain	Multistorey	1921-1945	3,03	1,67	1,26	0,37	5,7	0,1	3,50
60	Spain	Multistorey	1946-1960	3,03	1,67	1,26	0,37	5,7	0,1	3,20
61	Spain	Multistorey	1961-1975	1,71	1,92	1,72	0,21	5,7	0,1	3,00
62	Spain	Multistorey	1976-1990	1,71	1,92	1,72	0,16	5,7	0,125	2,70
63	Spain	Multistorey	1991-2005	0,58	0,60	2,20	0,75	3,4	0,125	3,00
64	Spain	Multistorey	>2005	0,48	0,47	0,91	0,42	3,3	0,125	3,00
65	Spain	detached house	<1900	0,24	5,56	2,38	0,72	5,0	0,095	3,60
66	Spain	detached house	1901-1920	2,56	3,08	0,85	0,69	4,3	0,095	3,60
67	Spain	detached house	1921-1945	2,56	3,08	0,85	0,69	4,3	0,1	3,30
68	Spain	detached house	1946-1960	2,56	1,60	1,83	0,32	4,6	0,1	3,00
69	Spain	detached house	1961-1975	1,33	1,37	0,85	1,01	4,6	0,1	3,00
70	Spain	detached house	1976-1990	1,33	1,37	0,85	1,01	4,6	0,125	3,00
71	Spain	detached house	1991-2005	0,62	0,52	0,89	0,88	3,2	0,125	3,00
72	Spain	detached house	>2005	0,48	0,47	2,16	0,55	3,1	0,125	3,00
73	Germany	apartment	<1859	2,00	2,60	1,20	0,529	2,8	0,095	4,00
74	Germany	apartment	1860-1918	2,20	1,30	1,20	0,300	2,7	0,095	4,00
75	Germany	apartment	1919-1948	1,70	1,40	1,00	0,636	3,0	0,1	3,80
76	Germany	apartment	1949-1957	1,20	1,60	2,20	0,663	3,0	0,1	3,80
77	Germany	apartment	1958-1968	1,20	0,60	1,60	0,432	3,0	0,1	3,80

Again, the user can modify numerical values and add rows paying attention not to mix Countries nor building types. Age blocks or building type are fully customizable.

All columns represent default values appearing in the first input page. Some of these values can be changed during tool operation after unchecking the default checkbox. Default data associated with the envelope elements, like the wall insulation or the windows, are available for adjustment in the sheet named "Envelope & Windows".

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Data Sheet 4/7

The third sheet, "Envelope & Windows", is dedicated to cost data for envelope interventions and windows substitution.These data can be easily modified by the user.

	1	2	3	4	5
1	EXTERNAL INSULATION	thermal conductivity	thickness	cost €/m2	installation cost € /m2
2	wall insulation	0,03	0,1	10	40
3	Roof insulation	0,03	0,1	10	20
4	Floor insulation	0,03	0,1	30	70
5					
6	single grazed cost, €/m2 (all inclusive)			300	
7	double glazed cost, €/m2 (all inclusive)			400	
8					

Thermal Conductivity is expressed in [W/(mK)] and thickness in [m].

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Data Sheet 5/7

The sheet "Heating & DHW" contains costs and efficiency related to heating and Domestic Hot Water devices.These data can be easily modified by the user.

	1	2	3	4	5	6	7	8	9	10
1	**HEATING (plant type)**	**efficiency**	**cost €/kW**	**installation cost €/kW**	**HEATING (emitter type)**	**efficiency**	**cost €/kW**	**installation cost €/kW**	**regulation: mean efficiency**	**distribution: mean efficiency**
2	1-Type B open chamber	0,76	20	10	1- Radiators	0,94	120	5	0,95	0,94
3	2-Type C sealed chamber	0,85	25	10	2- Radiators with Valve	0,95	200	5		
4	3- Gas/diesel modulating	0,83	35	15	3- Fan coil	0,95	60			
5	4- Condensing	0,94	45	15	4- Floor panels	0,96	500			
6	5- Gas/diesel on-off	0,87	30	10	5- Ceiling and wall panel	0,95	400			
7	6- Air cooled	0,87	30	10	6- Other types	0,92	9999999	9999999		
8										
9										
10										
11	pellet stove	0,88	80	10						
12	heat pump	2,5	300	50						
13	solar heating	0,5	500	100						
14	**plant type (hot water)**									
15	electric boiler (€/l)	0,9	5							
16	1- Open chamber centralized	0,76	20							
17	2- Sealed chamber autonomo	0,85	25							
18										
19										
20	heat pump (€/l)	2	8							
21	solar heater	0,8	500							
22										

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Data Sheet 6/7

The sheet "Other Thermal Data" contains some coefficient to tune the software. Airchangecoeff rules air leakages; results are very sensitive to changes in this parameter. The Shadow coefficient accounts for the exposition of the building and so for radiation heat transfer. Shadow=0 means no radiation at all. Alpha is the absorption coefficient (e.g. related to solar radiation) of the external plaster, whereas the sun factor is the transmissivity of the glassed surfaces (e.g. windows). DHW load represents the assumption of DHW consumption per person. A person each 25 m^2 is assumed. By changing the value you can easily make different hypotheses.

alfa (plaster)	0.70
sun factor (glass transmission coeff.)	0.65
shadow	0.30
Airchangecoeff [1/s]	0.33
DHWload [kg/person /day] 1 person=25 m2	30

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Data Sheet 7/7

The last "Variable Costs", is filled with energy costs year by year. Electric, gas, wood pellet costs are reported according to various units, country by Country. Other countries can be added with the same structures of those already present in the database. Data cover a time horizon of 30 years.

Default values for the discount rate are reported too.

	1	2	3	4	5	6	7	8	9	10	11	12
1	country	source	variation rate \ year	0	1	2	3	4	5	6	7	
2	italy	electric energy [€/kWh]	0,02	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,14
3		methane gas [€/Smc]	0,02	0,700	0,714	0,728	0,743	0,758	0,773	0,788	0,804	0,82
4		pellet [€/kg]	0,02	0,300	0,306	0,312	0,318	0,325	0,331	0,338	0,345	0,35
5		discount rate	0,08									
6	Lithuania	electric energy [€/kWh]	0,02	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,14
7		methane gas [€/Smc]	0,02	0,700	0,714	0,728	0,743	0,758	0,773	0,788	0,804	0,82
8		pellet [€/kg]	0,02	0,300	0,306	0,312	0,318	0,325	0,331	0,338	0,345	0,35
9		discount rate	0,09									
10	Spain	electric energy [€/kWh]	0,02	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,14
11		methane gas [€/Smc]	0,02	0,700	0,714	0,728	0,743	0,758	0,773	0,788	0,804	0,82
12		pellet [€/kg]	0,02	0,300	0,306	0,312	0,318	0,325	0,331	0,338	0,345	0,35
13		discount rate	0,07									
14	Germany	electric energy [€/kWh]	0,02	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,14
15		methane gas [€/Smc]	0,02	0,700	0,714	0,728	0,743	0,758	0,773	0,788	0,804	0,82
16		pellet [€/kg]	0,02	0,300	0,306	0,312	0,318	0,325	0,331	0,338	0,345	0,35
17		discount rate	0,1									
18												

In the above figure, values of energy increase with a constant rate but this is done only for our convenience. The software does not read the third column values (except for the discount rate) and the energy prices rows are completely up to the user.

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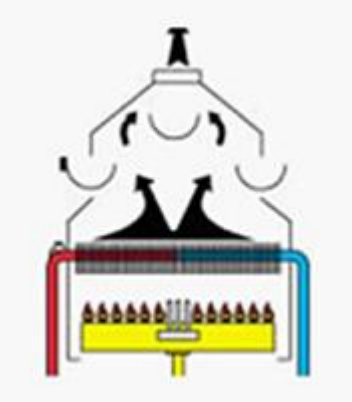
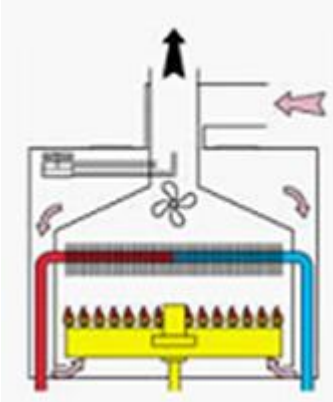
Heat Generators Description



Open Chamber. This boiler takes the air necessary for the combustion from the surrounding environment, therefore the combustion chamber is connected with the surrounding environment. The exhaust pipe is usually vertical and transports the exhaust gases outside. Usually these boilers should be installed outside in order to avoid the risk of forming carbon monoxide in the internal environment.



Sealed Chamber. The combustion chamber is sealed and it has no contact with the surrounding environment. Air for the combustion is taken outside by using a ventilation system and exhaust gases are expelled outside. This boiler can be installed in an internal environment.

Pictures taken from www.termostore.it

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